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Approaches to Modeling Retail-Farm Price Spreads and Derived Demand Relationships for Food Commodities

A Selected, Annotated Bibliography

Michael K. Wohlgenant
Richard C. Haidacher

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Keywords: Retail-farm price linkage, demand systems, price spreads, margins.

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The bibliography is divided into two sections: Derived Demand for Food Commodities and Theory of Derived Demand. This division is made to separate historical approaches to modeling price spreads and derived demand for food commodities from the more theoretical publications dealing with the general theory of derived demand.

The first section contains significant literature on modeling retail to farm demand linkages for food commodities. Studies reviewed range from markup pricing approaches to the more recent approaches derived directly from market equilibrium behavior. In the more recent literature, citations on the effect of input substitutability on derived demand for products are included.

The second section contains significant literature on derived demand for factors of production at both the firm and industry level. Studies reviewed contain historical references on development of neoclassical theory of the firm and industry as well as more recent developments using duality theory. This section includes studies that focus on either shortrun or longrun adjustment of the firm and industry to factor price changes. Most of the citations assume a competitive market structure, although a few explore the implications of alternative structures, including monopoly and sales maximization behavior.

Section I: Derived Demand for Food Commodities

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In this comment, Alston and Scobie examine the sensitivity of the Freebairn, Davis, and Edwards (FDE) (19)[1] results to their assumption of a zero elasticity of substitution (σ) between farm and nonfarm inputs used by the marketing sector to produce retail products. A simple two-factor competitive equilibrium model, which is not restricted to linear supply and demand curves nor to fixed proportions, is constructed. The assumptions, used by FDE of parallel shifts of supply curves induced by research and perfectly elastic supply of marketing services, are maintained. Using the FDE hog industry data and assuming alternative values for σ, Alston and Scobie calculate the gains to farmers and consumers due to shifts in the supply of marketing services and in farm supply. They conclude that the distribution of research benefits from various supply shifts is critically dependent on the elasticity of substitution, and even small values of σ (for example, 0.2) result in substantial differences in the distribution of benefits. Thus, FDE's result that the distribution of benefits is independent of the stage at which research shifts the supply curve only holds in

[1]Underlined numbers in parentheses refer to sources listed in this report.

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the special case of fixed proportions. Substitution between farm and nonfarm inputs offsets the scale effect of a change in the price of marketing services, moderating the effect of the change on the price spread. If substitution effects outweigh scale effects then, as Alston and Scobie note, producers may lose surplus as a result of a decrease in the price of marketing services. Efficiency gains in the processing sector have generally been viewed as a benefit to producers. However, Alston and Scobie's results indicate that farmers should not be indifferent to the stage at which research occurs. This situation has been given little attention in the literature even though, as Alston and Scobie point out, available evidence suggests that elasticities of substitution between the farm and marketing service inputs are not, in general, zero.

(2) Ball, Eldon V., and Robert G. Chambers. "An Economic Analysis of Technology in the Meat Products Industry," American Journal of Agricultural Economics. Vol. 64, 1982, pp. 699-708.

Significant structural changes in the meat products industry over the past two decades have created a need for knowledge about structural characteristics of the industry. Ball and Chambers use a dual cost function approach to address questions such as the extent and direction of factor substitution, economies of scale, and the ways in which technical change occurs. The theoretical framework (the dual relationship between cost and production functions, properties of the cost function, and derivation of cost minimizing input demands) is presented, followed by a discussion and comparison of various elasticity of substitution measures (Allen (52), Morishima(78) and McFadden (77)). A translog cost function was estimated, along with the share equations, using annual data from the 1954-76 period. Versions of the model considered were: a nonhomothetic version with non-neutral technical change; one consistent with homotheticity; one consistent with homogeneity; one consistent with linear homogeneity; and a nonhomothetic version with neutral technical change. Estimation results indicate that the null hypotheses of homotheticity, homogeneity, constant returns to scale, and neutral technical change are rejected. Local homotheticity was also ruled out due to negative values (inferiority) on the elasticity of input demand with respect to scale for the capital structures variable. The estimated Allen elasticities of substitution suggest that labor is a substitute for all other inputs and that capital is a complement of energy and materials. Since the Allen elasticity provides little information on relative input adjustments to a factor price change, Morishima elasticities were computed. Both of these elasticity measures show less evidence of complementarity than the Allen measure. Calculated scale elasticities indicated that the meat products industry was characterized by increasing returns to scale over the last 4-5 years. However, in addition to problems associated with scale elasticities calculated from time series data, the authors feel the scale effects may have been confounded with technical change in estimation. Ball and Chambers' results indicate that production in the meat products industry does not reflect homotheticity, homogeneity, or constant returns to scale; technical change is not neutral but rather labor saving and material using; and the classification of inputs as substitutes or complements depends critically on the elasticity measure used.

(3) Brandow, G.E. "Demand for Factors and Supply of Output in a Perfectly Competitive Industry," Journal of Farm Economics. Vol. 44, 1962, pp. 895-99.

Although industry analysis draws on the theory of the firm under perfect competition, two key problems cannot be overlooked: (1) the aggregation of functions for dissimilar firms into a single function for the industry, and (2) the prices of inputs and outputs fixed for a single firm are not fixed for the industry as a whole. Sidestepping the aggregation issue by assuming identical, linear homogeneous, production functions for all firms, Brandow focuses his attention on the second problem. A six-equation system, consisting of a Cobb-Douglas production function, supply functions for the farm and nonfarm inputs (where the elasticity of supply is allowed to be positive), an output-demand function (where the output demand elasticity can be negative), and equilibrium conditions (marginal value product equals factor price), is presented. This system is then used to derive expressions for the elasticity of input demand under three sets of ceteris paribus conditions: other input quantities constant, other input prices constant, neither prices nor quantities of other inputs constant. The own-price elasticity of demand for the farm input, with other inputs constant, is found to be elastic, unitary, or inelastic as output demand is elastic, unitary, or inelastic. The derived demand elasticity, however, does not depart from unity as widely as the output demand elasticity. In addition to these results, the input demand elasticities derived holding other input prices constant are found to be more elastic than those derived holding other input quantities constant. The cross-price elasticity of demand can also be calculated. It is negative, positive, or zero

depending on whether output demand is elastic, inelastic, or unit elastic. When neither prices nor quantities of other inputs are held constant, the elasticity of derived demand falls between the above two cases in magnitude. Thus, Brandow generalizes that demand for an input is elastic, unitary, or inelastic as output demand is elastic, unitary, or inelastic, regardless of what happens to prices and quantities of other inputs. The elasticity of output supply is also calculated and found to be non-negative. Other results from this calculation are: (1) if both inputs have the same supply elasticity, then the supply elasticity of output will also be the same, (2) if the supply of inputs is perfectly elastic so is the supply of output, and (3) if the quantity of inputs is fixed, so is the quantity of output. Although only the two input case is analyzed, Brandow notes that all results would hold for more than two inputs. He concludes with two remarks: (1) although demand for agricultural inputs is assumed to be inelastic, the shortrun demand may be elastic if the input is being used far below the optimal level initially, and (2) the Cobb-Douglas production function may overstate the substitution among factors, strengthening the presumption of inelastic factor demands.

(4) Brandow, G.E. Interrelations Among Demands for Farm Products and Implications for Control of Market Supply. Pennsylvania Agr. Exp. Bull. No. 680. Univ. Park, 1961.

In this study, a procedure for deriving farm level demand from retail demand is presented and applied. The key to this transformation lies in converting retail prices to farm prices by allowing for the marketing margins. Thus, information on how margins vary when prices and quantities change is essential. Quantity-dependent retail demand equations were estimated in logarithmic form. These equations were then expressed in natural unit form to facilitate subtraction of the marketing margins from retail prices. Farm and retail prices were connected via the relation: $p_i^* = p_i' - m_i$, where p_i^* = farm price of the i^{th} commodity, p_i' = retail price, and m_i = marketing margin. Next, attention is turned to how m_i varies with price and quantity changes, when price levels and the cost structure remain constant. Brandow notes that although margin behavior probably varies among food products, no satisfactory basis for distinguishing among products is available. Thus, based on earlier work by Buse and Brandow (10), the following margin rule was adopted: $m_i = F_i - d_i = F_i' + F_i'' - d_i$, where F_i = the spread per unit of farm quantity, d_i = the value of byproducts, F_i' = the portion of F_i that is constant per unit marketed, and F_i'' = the portion varying with the price of the product. Assuming values for these parameters and applying them to a number of food groups resulted in the following observations: (1) direct price elasticities of demand for the same end use are lower at the farm level than at retail and the relative differences are greatest for products with the highest marketing margins, (2) cross-price elasticities are lower at the farm level, (3) the effect of the price of one farm product on purchases for food of another is reduced if the first product has a high marketing margin, (4) farm level elasticities depend on the assumptions regarding the behavior of margins as prices and quantities change (that is, if the margin is a fixed percentage of the retail or farm price, the two elasticities are equal, whereas if the margin is fixed in absolute amount, most farm elasticities would be less than those at retail). One final caveat: the farm elasticities derived herein may be lower than implied by the relation of production to farm prices, due to the assumption that there is only a domestic use for the products and that the physical loss in marketing is a fixed percentage of the quantity sold at the farm. A commodity that can be stored, exported in volume, or has nonfood uses would have a much higher elasticity.

(5) Breimeyer, Harold F. "On Price Determination and Aggregate Price Theory," Journal of Farm Economics. Vol. 39, 1957, pp. 676-94.

In this article, Breimeyer makes a case for modifying conventional analysis and for taking greater account of institutional aspects of market pricing. He first takes issue with the assumption of perfect competition. Since price indeterminateness obviously exists whenever a single buyer and seller meet, whether negotiation is for barter or for cash sale, he feels there is a need to look beyond the perfectly competitive model. Aside from the issue that most price analyses are built on the theoretical premises of equilibrium he faults another standard procedure, the use of national total or average data. Two weaknesses in over aggregation are noted: (1) research becomes directed at questions too far removed from actual concerns of marketers, consumers, and producers, and (2) aggregate equilibrium analysis connotes an efficiency of the marketing and pricing process that is not justified. A negative effect of this overtrust in the workings of the price determining mechanism, according to Breimeyer, is decreased interest in examining the actual performance of pricing in individual sales. A third inadequacy in price analysis noted by Breimeyer is the

tendency to interpret economic events in terms of demand alone. The supply curve and its shifts deserve a closer look. Reservation demand is defined and the usefulness of this concept discussed. Finally, Breimeyer urges additional studies in the area of marketing margins. Constant margins (fixed or percentage) are usually assumed. Breimeyer asserts, however, that while constancy in margins may be true over a number of years, it does not hold within a short time period or at least not for commodities subject to competitive pricing. Margins for marketing food products are subject to three influences: (1) changes in costs of marketing inputs (labor and packaging materials), (2) the amount of processing and services rendered, and (3) the volume of product handled. The importance of each depends on the length of the time period and the product.

(6) Brock, Peter, and Gordon C. Rausser. "Consumer Demand, Grades, Brands and Margin Relationships," New Directions in Econometric Modeling and Forecasting in U.S. Agriculture. G.C. Rausser (ed.). New York: Elsevier/North-Holland Publishing Co., 1981.

In developing a monopolistic margin model, the authors start from the premise that most econometric investigations of the U.S. food and agriculture sector ignore variations in quality by modeling intermediary behavior as a constant- or percentage-margin relationship. They argue that forecasting the effect of many food policies requires a representation that extends beyond the competitive paradigm. In the first section of the publication, the authors formulate a model in which the role of information in the demand for brands and grades can be examined. The equilibrium conditions for monopolistic competition under product uncertainty are then addressed and the model extended to predict product brand and grade entry. Finally, they discuss margin relationships. Margins are defined as the difference between retail price and raw materials cost (farm price). Substituting the monopolistic competition solution for retail price, the authors arrive at a margin specification for the monopolist which allows a comparison between the monopolistic margin structure and the typically employed purely competitive structure. The distinction between the two centers on the influence of raw materials costs. A test for monopolistic competition, which requires time series data on margins and raw product costs, was developed, and an example using the translog functional form was provided. The following differences were noted as a means of distinguishing a competitive margin structure from a monopolistic one: (1) an increase in retail demand has a positive effect on competitive margins, but has an ambiguous effect on monopolistic margins, (2) food-processing input prices have positive effects on both margin structures, (3) advertising has a positive effect on the monopolistic margin, but no effect on the competitive margin, and (4) raw product prices have a negative effect on monopolistic margins, but no effect on the competitive margin.

(7) Brorson, B. Wade, Jean-Paul Chavas, Warren Grant, and L.D. Schnake. "Marketing Margins and Price Uncertainty: The Case of the U.S. Wheat Market," American Journal of Agricultural Economics. Vol. 67, 1985, pp. 521-28.

This publication presents theoretical and empirical results of the effect of output price risk on marketing margins. The theoretical model shows that if marketing firms are competitive and exhibit decreasing absolute risk aversion, then an increase in output price risk will result in higher marketing margins. The model is applied to wheat markets for both farm mill and mill retail margins. Results are consistent with model specification and indicate potential benefits from a price stabilization program.

(8) Bunkers, E.W., and Willard W. Cochrane. "On the Income Elasticity of Food Services," The Review of Economics and Statistics. Vol. 33, 1957, pp. 211-17.

Bunkers and Cochrane contend that although increases in real income and per capita food expenditures appear incongruous with constant per capita food consumption, consumer behavior with respect to the raw farm produce remains rational and consistent. They note that aggregate food consumption, which can be partitioned into farm food products and off-farm food services, has both hidden structural changes in food purchases and changes in the resource mix going into food products. Single-equation, income-consumption relations were estimated to test the hypothesis that the income elasticity for farm food products is relatively low, while that for off-farm food services is relatively high. Finding and constructing a satisfactory data series for the dependent variables, real value of farm food products, and real value of off-farm food services, was the main stumbling block. The farm value and market value series of civilian

purchases of farm food products were used to derive reasonable proxies for the respective variables. After experimenting with several specifications, the following linear relations were estimated using annual data from the 1913-54 period: (1) farm food product consumption as a function of disposable personal income and time; (2) off-farm food service consumption as a function of disposable personal income, index of off-farm food service prices divided by the index of farm food product prices, and time; and (3) food product consumption as a function of disposable personal income, index of retail food prices divided by index of retail nonfood prices, and time. All equations were estimated on both a consumer food-spending unit basis and an adult-equivalent basis. The adult-equivalent specification consistently yielded a better fit as indicated by the higher R^2 and t-values. Income-farm food product consumption elasticities were low (0.25 - 0.28), while income-off-farm food service consumption elasticities were relatively high (0.96 - 1.32). The aggregate relation elasticities fell between the high and low values as expected. Thus, the results substantiate the stated hypothesis. Bunkers and Cochrane conclude with a brief discussion of the implications of these results for food and agricultural industries. In particular, they note that the future of food processing and service industries looks bright since consumer purchases of these services are expected to increase more than proportionally as real income increases.

(9) Burk, Marguerite C. "Some Analyses of Income-Food Relationships," Journal of American Statistical Association. Vol. 53, 1958, pp. 905-27.

Burk's stated objective was to describe and differentiate among various measures of food consumption through time and at specific points in time and to compare the results of regressions with these measures and income. Three broad classes of data on income-food relationships (time series data on income and the value and quantity of food, cross-sectional surveys through time, and cross-sectional data for a single period) are presented along with the limitations associated with each. Alternative time series measurements of food consumption were described in depth. Single-equation, income-food relationships were estimated using a double-log functional form. The principal quantity and value measures of food consumption described in the publication were used as the dependent variables and the time series results were compared, not only with regard to choice of the dependent variable, but also with respect to the cross-sectional results. Cross-sectional survey data were used to predict changes in market value and consumption based on population characteristics. Some major findings of this study are: (1) relationships between real income and quantity measures of food consumption changed little from 1938 to 1958, (2) the level of food-marketing services has increased significantly, (3) the change in the level of food-marketing services resulted in higher post-World War II levels of market value of all food consumed and food expenditures in relation to income, which in turn resulted in lower income elasticities, (4) cross-sectional data indicated that the major increases in demand have come primarily from rural households and low-income urban households, and (5) increases in the average consumption of food from all sources resulted from higher incomes, whereas use of food-marketing services exceeded all expectations.

(10) Buse, Reuben C., and G.E. Brandow. "The Relationship of Volume, Prices and Costs to Marketing Margins for Farm Foods," Journal of Farm Economics. Vol. 42, 1960, pp. 362-70.

Marketing margins for 20 commodities were estimated using both annual and quarterly data. An individual commodity's marketing margin was specified as a linear function of the farm/retail spread for the market basket of farm foods, per capita consumption, retail price, a price direction indicator, and a time trend. A combined (absolute and percentage) variable margin, with fixed proportions assumed, is implicit in this specification. Results are reported in elasticity form and support Ogren's (38) finding that changes in the farm/retail spread over time are primarily determined by changes in the cost of factors involved in processing and distribution. The market basket of farm food was found to reflect these factors better than any other series and 85 percent of the variation in annual margins was accounted for by changes in this variable. The relation between the margin and consumption was less clear. However, a negative relationship was found in most cases. The effect of retail price on margins was clearly positive. In addition, it was noted that two types of changes are involved: one in which margins play a passive role (they only change because retail price changes) and another in which they play an active role (that is, changes in costs or administrative pricing unrelated to costs imply margins partially influence retail price and elasticities).

(11) Chambers, Robert G. "International Trade, Gross Substitutability, and the Domestic Farm-Retail Price Margin," European Review of Agricultural Economics. Vol. 10, 1983, pp. 33-53.

In this publication, the effect of international trade and government intervention on the farm/retail price ratio is examined using a two-country, one-commodity, two-factor model. Chambers extends Gardner's (22) analysis on determinants of the retail/farm price ratio to allow for the possibility of international trade in both the retail food commodity and in the raw agricultural commodity. However, Chamber's approach is based on a firm level profit function, which is used to generate firm level supply and derived demand, whereas Gardner's analysis is predicated on the existence of an industry level production function exhibiting constant returns to scale. The model is founded on the following assumptions: (1) both the final food commodity and the raw agricultural input are traded internationally, but the processing input is not, (2) the home country exports the final food product and the foreign country exports the raw agricultural input, (3) price barriers are present, (4) the home country drives a wedge between the price its citizens pay for the final food and the price charged abroad and the foreign country responds (reaction function) by discrimination in its export market, and (5) gross substitutability between inputs is assumed in presenting the theoretical model to make the mathematics tractable. The major findings of the publication are: (1) results, when comparable, were similar to Gardner's (22), (2) assuming gross substitutability, an outward shift in the supply of the agricultural commodity leads to an increase in the farm/retail price margin, and an outward shift in retail demand also increases the margin, (3) the retail/processing input price ratio will move in the same direction as the retail/farm price ratio in response to a change in the supply of the agricultural commodity if the farm and processing inputs are very substitutable in the domestic industry and not very substitutable in the foreign processing industry, (4) unambiguous conclusions for the effect of a change in the domestic government trade policy are not possible (however, it does appear that increased intervention leads to a decrease in the retail/farm price ratio when there are marked differences in international technologies), (5) if processing technologies are very similar, there is the possibility of increased intervention causing an increase in the retail/processing input ratio, and (6) numerical analysis suggests that the theoretical results for the retail/farm price ratio are relatively robust to relaxation of the gross substitutability assumption.

(12) Dalrymple, Dana G. On the Nature of Marketing Margins. Agr. Econ. Mimeo No. 824. Michigan Agr. Exp. Sta., 1961.

Discussion focuses on systematic margins, as defined by Hoos (28). Constant absolute and percentage margins are defined, including graphical illustrations. Implications of the margin form on farm-retail elasticities are discussed and shown algebraically, that is, constant absolute margin implies that farm demand is less elastic than retail demand, while constant percentage implies that the two elasticities are the same. Variable margins are also defined and it is noted that their effects on the elasticities are more difficult to discern. A hypothesis forwarded, with respect to variable percentage margins, relates increases (decreases) in the rate of change of the margin in the elastic (inelastic) portion of the demand curve with an opposite (similar) change in the elasticity of demand. A graphical demonstration is provided. A number of studies are cited; documenting wholesale margin behavior as that of constant percentage markup; retail behavior as constant, or variable absolute markup; and thus, the aggregate behavior as a combination. This paper provides a brief overview of margin models, their implications and related research and, in conclusion, underscores the need for further investigation into margin behavior.

(13) Daly, Rex F. "Demand for Farm Products at Retail and the Farm Level, Some Empirical Measurements and Related Problems," Journal of American Statistical Association. Vol. 53, 1958, pp. 656-68.

Using data on retail expenditures for food and the marketing bill and farm value, price and income elasticities, and the flexibility of expenditures with respect to income are obtained and discussed. Consumer expenditures for food are estimated as a function of income. Then, noting that both expenditures and income have price and quantity components, another set of equations is estimated, relating the price component to expenditures and income, and the quantity component to expenditures and income. Results indicate that more than 75 percent of the variation in retail expenditures is associated with price changes, while less than 25 percent is due to quantity changes. On the other hand, nearly half

the variation in per capita money income is associated with changes in real income. The elasticity resulting after the removal of price influences is much smaller than the elasticity of money expenditure with respect to money income. The same approach is taken in calculating the elasticity of the marketing margin quantity with respect to income and the income elasticity of derived demand. Results indicate that about 60 percent of a change in the marketing bill is associated with price changes. As expected, the removal of price influences produces a smaller elasticity of marketing-margin quantity with respect to income. Changes in the price component of the marketing bill are found to be proportional to changes in the Consumer Price Index. A final result is that the demand for services is more responsive to income changes than consumer expenditures for food. The estimate of the income elasticity of derived demand is 0.13. Increases in consumption are mostly due to changes in quality and not quantity of food consumed. Finally, the calculations indicate that when price influences are eliminated, the quantity of services used in processing and marketing farm products is much more responsive to income changes than is the per capita consumption of food at the farm level. The last section of the article focuses on the differences between partial and total elasticities of demand using algebraic and graphical illustrations.

(14) Dunn, James, and Dale Heien. "The Demand for Farm Output," Western Journal of Agricultural Economics. Vol. 10, 1985, pp. 13-22.

In a departure from previous research endeavors on the derived demand for farm output, Dunn and Heien studied the aggregate food sector and considered the various processing and distribution costs as a set of interrelated factor demands. A dual cost function approach was taken. Share equations for farm outputs (meat, dairy, poultry, fruits, and vegetables) and marketing inputs (labor, packaging, transportation, and all others) were derived from the translog cost function and estimated using aggregate annual time series data. Homogeneity and symmetry were imposed. The test for substitution between farm outputs failed to reject the null hypothesis of zero substitution, and a specification including time as a measure of technical change indicated that time was not a significant variable. Elasticities for each factor with respect to all factor prices, capital stock, and output were computed. These elasticity estimates were combined with prior knowledge of the retail demand elasticity to obtain a reduced-form expression for the demand for farm output. The system (the demand for farm output, the marginal cost pricing rule, and the retail demand) was specified in double-log form and the resulting reduced-form equation expressed farm output as a function of farm prices, prices of marketing inputs, consumer income, nonfood retail prices, and capital stock. Results supported the Brandow (3), and George and King (23) findings: farm own-price elasticities are considerably smaller than corresponding retail own-price elasticities. The model was also solved for farm price and flexibility matrices were calculated. Results indicate that, with the exception of own-quantity, capital stock has the greatest influence on gross farm receipts, even though the role of capital stock is typically ignored in studies of this nature. Dunn and Heien summarize the article's major findings as follows: (1) demand for each category of farm output is price inelastic and less than its retail counterpart, (2) the role of capital is significant in determining the demand for the farm output, (3) no statistically significant substitution exists among various farm outputs and very little between farm outputs and other inputs, (4) an increase in processing and distribution input prices has a significant depressing effect on farm output demand, and (5) consumer income and nonfood prices have a significant effect on farm demand.

(15) Edwards, Clark. "Demand Elasticity in the Factor Market as Implied by Cobb-Douglas Production Functions," Journal of Farm Economics. Vol. 43, 1961, p. 142

The Cobb-Douglas production function is commonly used in empirical work to derive the profit-maximizing input demand functions. However, under conditions of diminishing marginal returns, it is shown that this functional form precludes inelastic factor demand schedules. Thus, Edwards concludes that the Cobb-Douglas production function is inappropriate when deriving the factor demands for farm resources which are expected to be inelastic.

(16) Fisher, B.S. "The Impact of Changing Marketing Margins on Farm Prices," American Journal of Agricultural Economics. Vol. 63, 1981, pp. 261-63.

Changes in the costs of marketing services originate from two sources: changes associated with the introduction of new services or changes in the costs of existing services. Fisher addresses only the latter case where a change in the marketing margin is the result of an exogenous shift in the supply of existing marketing services (for example, an increase in real wages or fuel prices). The effect of this change on retail and farm prices is examined both graphically and mathematically. The graphical analysis assumes a perfectly elastic supply of marketing services and considers cases of positive, zero, and negative elasticity of farm supply. By breaking down the change in the marketing margin into its effect on farm and retail prices, and assuming linear supply and demand curves, an equation is derived expressing the proportion of the increase in the marketing margin borne by the farmer as a function of the elasticity of farm supply, the retail demand elasticity, and the farm/retail price ratio. If the elasticity of farm supply is zero, farmers pay 100 percent of the increase in marketing charges. If the supply elasticity equals the product of the farmer's share of the retail dollar and the retail demand elasticity, the charges are shared equally by producers and consumers. Fisher relaxes the zero elasticity of substitution assumption by solving the Gardner (22) equation system and deriving a new expression for the proportion of the increase margin borne by the farmer. As the elasticity of substitution approaches zero, this expression collapses to Fisher's original equation. Assuming it is zero, Fisher simulates how the burden of an exogenous change in marketing charges will be shared between consumers and producers under alternative values for the elasticities. Results from this simulation indicate that for most agricultural products, the major adjustment to changes in marketing charges will be made by farm prices, implying farmers have a strong economic incentive to promote efficiency in the service sector. As a final point, Fisher discusses the case of a negatively sloped supply function, a situation which may occur in the short run in the beef industry. Under such conditions, the derived demand for marketing services is positively sloped and market equilibrium may not be reached.

(17) Foote, R.J. Analytical Tools for Studying Demand and Price Structures. AH-146. U.S. Dept. Agr., Econ. Res. Serv., 1958, pp. 100-10.

The structural model and results from Hildreth and Jarrett (27) serve as a starting point in this analysis. Rather than reproduce the comparative statics, the publication concentrates on the implications of the Hildreth and Jarrett results, including an algebraic proof of why the elasticity of derived demand is less than the retail demand elasticity in cases of a constant percentage or absolute margin or when the margin is an increasing monotonic function of quantity. The report also analyzes the relationship between the elasticity of supply at retail (the partially reduced-form supply elasticity) and the producer supply elasticity, with results that are less clear than those for the demand elasticities. In conclusion, the publication addresses estimation issues noting that, unless we assume the margin is not a function of quantity and have knowledge of the elasticity of price transmission, we cannot calculate the retail demand elasticity from the derived demand elasticity.

(18) Fox, Karl A. "Factors Affecting Farm Income, Farm Prices and Food Consumption," Agricultural Economics Research. Vol. 3, 1951, pp. 65-82.

Factors affecting the general level of farm income (disposable income, changing marketing margins, government price supports, and export demand) are discussed. Fox notes that the marketing margins of food crops vary greatly due to differences in marketing channels, transportation requirements, degree of processing, and seasonality. The remainder of the article focuses on the factors affecting farm price. Using a log-linear functional form, both price-dependent and quantity-dependent demand equations were estimated. Farm price was estimated both as a function of retail price and as a function of quantity consumed and income. Results support the notion that farm prices are more volatile than retail prices because of the presence of fixed costs or charges in the marketing system. In addition, if there are any fixed elements in the marketing margin, the elasticity of demand at the consumer level will be greater than at the farm level. Other results pertain to specific commodities. For example, butter was found to have the smallest marketing margin and the smallest percentage relationship between farm and retail price changes. Finally, the time series results were compared with cross-sectional results from family budget data.

(19) Freebairn, J.W., J.S. Davis, and G.W. Edwards. "Distribution of Research Gains in Multistage Production Systems," American Journal of Agricultural Economics. Vol. 64, 1982, pp. 39-46.

Considering agricultural production as a three-stage process (input supply, farm production, and farm-to-retail marketing), the authors examine the effect of research at one stage of the production chain on other production stages and on consumers. Aggregate benefits (changes in economic surplus) were measured as well as the distribution of benefits. The effect of cost-reducing research at each stage was viewed as a parallel, downward shift in the supply curve of goods and services at that stage. Assuming a perfectly elastic supply of nonfarm inputs and of marketing goods and services, the authors present a simple graphical and algebraic model to compare the effects of shifts in farm and marketing service supply that results from cost-reducing research. Following this analysis, a more general five-equation competitive equilibrium model is developed, which allows for positively sloped supply functions, while still maintaining the assumption of fixed proportions between farm and nonfarm inputs in the production process. The authors concluded that research-induced cost reductions in one stage of the system will provide benefits to consumers and all other members of the production system. Under assumptions of competitive behavior, linear supply and demand curves and fixed proportions, the distribution of aggregate research benefits is the same regardless of whether the cost reductions occur in the nonfarm, input, farm, or marketing sector. The relative distribution of benefits was found to be dependent on the retail demand elasticity and the various value-added supply elasticities at each stage. Aggregate benefits were little affected by the various demand and supply price elasticities. The competitive model was applied to the U.S. hog industry and results supported the general conclusions given above. The authors considered the imperfectly competitive case and found that results were modified but not overturned.

(20) Freebairn, J.W., J.S. Davis, and G.W. Edwards. "Distribution of Research Gains in Multistage Production Systems: Reply," American Journal of Agricultural Economics. Vol. 65, 1983, pp. 357-59.

Although Freebairn, Davis, and Edwards accept the argument presented by Alston and Scobie (1) and agree that the elasticity of substitution is important, they focus on other points. Another issue which deserves further attention, and is noted in this response, is that not only may input ratios change in response to price ratio changes, but the product may change as well.

(21) Freebairn, J.W. "Farm and Retail Food Prices," Review of Marketing and Agricultural Economics. Vol. 52, 1984, pp. 71-90.

This article examines the contribution of farm food prices and nonfarm input costs to changes in retail food prices. Using monthly data for the 1970's, Freebairn estimates two versions of a dynamic price-markup model for meats, fresh fruits and vegetables, eggs, and cereal products. The first version (Heien's (25) model), regresses retail price on current and lagged farm prices, dummy variables for periods of increasing and decreasing prices, and wage rates (proxy for nonfarm input costs). The second approach (a variation of Lamm and Westcott's (31) model) includes the above variables plus measures of demand shifts, income, last period's retail price of a substitute product, and monthly dummies. A zero elasticity of substitution is considered to be a tolerable assumption for the commodities analyzed implying that parameter values are constant and not a function of farm prices and input costs. All explanatory variables were regarded as predetermined for estimation. Sim's causality tests were applied to the sample data and results were used to justify the assumption of predetermined explanatory variables. The augmented markup model (the second version) was found to be superior based on evaluation criteria (parameter signs, magnitudes, and coefficient of determination). Demand pressures as well as farm and nonfarm input costs were found to significantly influence retail food prices. Changes in farm prices had significant effects on retail prices of all commodities analyzed and, as expected, higher wages had a significant positive effect on retail prices. Results indicated that most of the variation in retail food prices can be explained by changes in current farm prices, lagged values of farm price, wage rates and, for some commodities, the lagged retail price of a substitute commodity. Adjustment lags of several months were found between changes in farm and retail prices. In concluding, Freebairn notes that, while the generalized price markup model provided a reasonable explanation of retail food prices, high levels of autocorrelation and parameter instability in about half the equations suggest an opportunity for improved model specification.

(22) Gardner, Bruce L. "The Farm-Retail Price Spread in a Competitive Food Industry," American Journal of Agricultural Economics. Vol. 57, 1975, pp. 399-409.

A one-product, two-factor (farm and nonfarm) competitive equilibrium model of a food-marketing industry is constructed to determine how various shifts in the demand for and supply of food affect the retail/farm price ratio and the farmer's share of retail food expenditures. The model, based on the work of Allen (52) and Hicks (74), consists of a constant returns-to-scale production function, a demand function, price-dependent input supply equations, and input demand functions where input price is equated to marginal value product. This system of equations was solved for the six endogenous variables (quantities and prices of the inputs and product) in terms of exogenous shifters of product demand and farm and nonfarm input supplies. Using these reduced-form equations, Gardner examined the conditions under which a change in the retail/farm price ratio could be predicted from changes in each of the exogenous shifters. The following specific results were obtained: (1) a change in the retail/farm price ratio due to a shift in product demand is dependent on the relative magnitudes of the input supply elasticities, (2) the retail/farm price ratio will increase with an increase in the supply of farm products and decrease with an increase in the supply of marketing inputs, (3) the percentage price spread is analytically distinct from the farmer's share of the food dollar and the two will behave differently under changing market conditions unless the elasticity of substitution equals zero, and (4) the elasticity of substitution for marketing inputs can be estimated by dividing observed changes in the farmer's share by observed changes in the farm/retail price ratio. Gardner's approach allows for a nonzero elasticity of substitution between the farm and nonfarm inputs, and thus the magnitude of error in the traditional fixed proportions assumption can be quantified. Gardner's results imply that no simple markup-pricing rule (fixed percentage, fixed absolute, or a combination of the two) can accurately depict the relationship between farm and retail prices. Thus, he suggests that the Waugh (47), and George and King (23) marketing-margin models are misspecified since they imply a fixed relationship between retail price and the price spread. Retail price, Gardner argues, is influenced by both changes in input supply and consumer demand; hence, a fixed relationship can only be maintained if supply and demand move together. Two limitations to the model are noted: it assumes competition, and it aggregates all marketing activities into one production function and all nonfarm marketing inputs into one quantity.

(23) George, P.S., and G.A. King. Consumer Demand for Food Commodities in the United States with Projections for 1980. Giannini Foundation Monograph No. 26. Berkeley, CA., Mar. 1971.

Four types of margin behavior are summarized: (1) constant percentage of retail price, (2) constant absolute amount, (3) linear function of quantity marketed, and (4) combination percentage and absolute. Using a combination margin, equations for 32 commodities were estimated. The significance of intercept and slope terms suggested the appropriate margin specification, which was a combination of percentage and absolute amount in most instances. To address the effect of margin behavior on derived demand, the model presented was similar to that of Hildreth and Jarrett (27); however, the two approaches diverge. Hildreth and Jarrett totally displace the equilibrium equations in their model to get an expression for the derived demand elasticity. The expression is simplified by applying prior knowledge and assumptions to various terms. Then, the marketing margin behavior implied by these assumptions is discussed. George and King, in comparison, start with the Hildreth and Jarrett model, presumably to indicate the relationship among variables, but proceed by selecting a specific margin behavior, that is, a linear function of retail price. By manipulating this equation, they show that the derived demand elasticity can be expressed as the product of retail demand elasticity and the elasticity of price transmission between retail and farm prices, where the elasticity is expressed as a function of parameters of linear margin behavior. The cases of constant percentage and constant absolute margins are shown to be special cases of this more general form when the intercept of the margin equation is zero and when the slope is zero. The variable quantity margin case is not addressed, and fixed proportions between the agricultural input and output are assumed throughout.

(24) Griliches, Zvi. "The Demand for Inputs in Agriculture and a Derived Supply Elasticity," Journal of Farm Economics. Vol. 41, 1959, pp. 309-22.

Griliches notes that while the structure of agricultural factor markets is of great interest, quantitative information concerning them is scant. In this article, he provides a synopsis of the existing factor demand studies for three representative inputs: fertilizer, tractors, and hired labor. All studies reviewed have a common theoretical and statistical framework: (1) demand for a factor is treated as a derived demand, (2) the desired level of use is a function of the expected product price, the price of the factor, prices of other factors, and the rate of interest, (3) the desired level of use equals the actual level only in the long run, and (4) a distributed lag model is used. Most of the studies used aggregate time series data. However, in the case of fertilizer, the analysis was also carried out on a regional basis, a commodity basis, and a cross-sectional basis. One noteworthy result from a comparison of the price elasticity of fertilizer used on cotton with the price elasticity of fertilizer used per-cotton acre shows that the difference between them is the price elasticity of cotton acres. Griliches also offers comments on the paucity of data on many inputs and on the usefulness of the distributed lag model. In addition to summarizing a series of reports dealing with the estimation of demand functions for selected farm inputs, Griliches illustrates the relevance of these results for supply analysis by deriving the supply elasticity implied by the estimated input demand elasticities. Any supply elasticity, he states, can be expressed as the weighted average of all the elasticities of demand for individual inputs with respect to the product price. Assuming perfect competition, factors are paid their marginal value products and the appropriate weights are their factor shares. Although all that is necessary for an estimate of the aggregate supply elasticity of farm products are estimates of demand elasticities of all inputs and their distributive shares, this information is usually not available. Griliches stresses that the supply elasticity derived by this process is a partial or relative supply elasticity and not a total or absolute elasticity, since when factor supplies are not perfectly elastic, these two concepts will differ. This article emphasizes that parameters of input demand functions are tied closely to parameters of the output supply function.

(25) Heien, Dale M. "Markup Pricing in a Dynamic Model of the Food Industry," American Journal of Agricultural Economics. Vol. 62, 1980, pp. 10-18.

Heien presents a dynamic theory of food price determination for farm, wholesale, and retail sectors. The approach is similar to Gardner's (22) with one major difference: Heien's model does not assume that retail, wholesale, and farm level demands equal their respective supplies, that is, the model allows for disequilibrium. Heien rejects the excess demand approach, used by some researchers to specify this imbalance, as inappropriate for some levels of the food distribution system (for example, retail level) in favor of an operationally more realistic theory: a markup-over-costs approach. He then proves that the markup approach is consistent with economic theory under the assumptions of constant returns to scale and a Leontief production function (arguing that in the shortrun, fixed proportions is a valid assumption). Heien proceeds to demonstrate how the Leontief constant returns to scale relationship for retail price can be used as a consistent pricing rule in a disequilibrium model where time is required to make adjustments. The model is closed by setting the current period's supply equal to the last period's demand. In testing for stability of the theoretical model, Heien found that both damped and explosive oscillatory growth, as well as convergent growth, result. The remainder of the article was devoted to an empirical test of one component of the theory presented, namely, the markup-pricing rule. Sim's causality tests were applied to 23 food items using monthly data to test the validity of the underlying assumption that farm prices cause retail prices. In general, the results supported the assumptions; however, important exceptions were noted. Empirical tests of the markup-pricing rule were conducted next. A distributed lag model, in which retail price is specified as a function of current and lagged wholesale prices, unit labor costs for retail food stores, and the unemployment rate, was estimated for 22 commodities using monthly data. A Wolffram-Houck procedure was used to conduct asymmetry tests to determine whether retailers treat wholesale price increases differently from price decreases. The hypothesis of asymmetry was rejected. Heien also rejected the hypothesis of structural change in 15 of 22 commodities.

(26) Heien, Dale M. "Price Determination Processes for Agricultural Sector Models," American Journal of Agricultural Economics. Vol. 59, 1977, pp. 126-36

Heien reviews the traditional price-determination process for agriculture, points out its drawbacks, and suggests improved methods. Heien characterizes the traditional price-determination process as follows: supply is a function of lagged prices, government programs, and carryover; output and price expectation determine stocks; demand is the difference between supply and stocks; and demand is a function of prices and income. This approach places a large burden on the stocks equation in the price-determination process. Heien lists several reasons why improvement of these equations is difficult, implying that there is little payoff from attempts to improve the standard approach via this method. Next, he criticizes the notion of enumerating variables and equations, which is reinforced by a tradition of linear specifications and matrix solutions, for further obscuring the price-determination process. Solution techniques such as the Gauss-Seidel require normalization which implies that each variable has a unique causal structure. Heien summarizes the economic significance of this: a completely recursive system becomes, when aggregated over time (days - years), a simultaneous system normalized in the Gauss-Seidel manner. This, he states, implies that the traditional supply, demand, and stocks specification is erroneous. The resulting simultaneous model is normalized in a causative sense and, therefore, counting of equations and unknowns no longer suffices. One of the equations must be normalized on price and Heien's solution to this problem is the introduction of the idea of price dependency in the demand equation. A theoretical approach incorporating the notion of price dependency is developed. This model is conceptually similar to Gardner's (22). However, empirical implementation requires that normalization decisions be made for each relation. Price-dependent factor demand curves are derived using this framework and empirical applications of the relations are presented for beef and pork.

(27) Hildreth, C., and F.G. Jarrett. A Statistical Study of Livestock Production and Marketing. Chapter 7, pp. 107-12. Cowles Commission Monograph No. 15. NY: John Wiley and Sons, Inc., 1955.

Functional relationships are specified for producer supply, processor behavior, and consumer demand (under the assumption that net imports and stocks are negligible, the processor supply and demand equations can be reduced to one equation). Ignoring exogenous factors, producer supply and consumer demand relations are functions of own price (that is, farm and retail price, respectively) and quantity, while processor behavior is a function of both prices and quantity. Retail price is eliminated from the processor behavior and consumer demand relations to obtain derived demand for the farm input. Total differentiation of the equations and comparative statics show that the farm/retail elasticity relationship is dependent on the specification of the processor behavior relations. Specifically, it is shown that in cases where the processor's behavior is a function of quantity (that is, constant margins), the farm price elasticity equals the retail price elasticity times the elasticity of price transmission between retail and farm prices. Their analysis is not confined to the constant margin case. Allowing processor behavior to be a function of quantity (that is, variable margins) and assuming: (1) the margin is an increasing function of quantity marketed, and (2) the elasticity of price transmission is less than 1, they show that consumer demand is at least as elastic as derived demand.

(28) Hoos, Sidney. Weekly Prices and Retail Margins - Small, Medium, and Large. Giannini Foundation Report No. 170, Berkeley, CA, 1954.

Conventional approaches to explaining price or margin-setting behavior (profit-maximizing marginalism and full cost or margin-over-cost) ignore the fact that pricing procedures are dependent on the conditions and circumstances of a particular store. In this publication, Hoos reviews various price- and margin-setting practices, both systematic and nonsystematic. Although the type of product, as well as the type of store, may influence the policy and practice of product pricing, empirical evidence from the citrus industry is used to draw correlations between store type and pricing procedure. In addition, the resulting retail price from these pricing schemes is compared with that of shortrun profit maximization. The systematic pricing practices discussed include: (1) fixed absolute margin, (2) fixed percentage margin, and (3) a combination margin where the cents-per-pound margin varies with either the sales or purchase price. The fixed absolute margin was used more by the medium- and small-sized stores with a single owner and manager decisionmaker. The retail price resulting from this procedure does not usually correspond with that of

profit maximization; however, the merchant may be foregoing shortrun profits in favor of other benefits such as ease of application. Fixed-percentage margins were widely used for fresh citrus. Again, this practice need not yield a retail price equivalent to shortrun profit maximization. Although, at an appropriate volume, the two could coincide. The combination margin and absolute margin are used more by the larger stores. Nonsystematic margins, where the primary factor in retail price setting is "what the competition is doing," characterize a smaller number of stores and include such practices as: (1) meeting competition (price follower), (2) shading (setting price below competition), and (3) padding (setting price slightly higher). Relationships between retail and wholesale price flexibilities and the gross profit-maximization margin are discussed for cases of both perfect and imperfect competition. In addition, relations between the absolute margin, returns to store, and volume of sales are presented to underscore that margins are indicators of the market value of services performed. The final section of the publication deals with how margins are established for a firm with multiple-products and concludes that experience and intuition are the dominant factors in margin setting on a multiple product basis. In conclusion, various systems of margin setting were sketched and reviewed in terms of their characteristics and relation to economic concepts such as demand price flexibilities and profit maximization. Different procedures are used by different merchants, and at times, yield results that approach those of profit maximization. No unique relation need exist between the level of profits a firm realizes and the degree of sophistication in its setting of margins and prices. Hoos conjectures that perhaps stores strive for some particular level of longrun profits in selecting a margin-setting procedure.

(29) Kinnucan, Henry W., and Olan D. Forker. "Asymmetry in Farm-Retail Price Transmission for Major Dairy Products," American Journal of Agricultural Economics. Vol. 69, 1987, pp. 285-92.

The link between the farm level price of milk and the retail level price of fluid milk, cheese, butter, and ice cream was empirically analyzed in this article. These four dairy products represented 95 percent of farm milk use. Results indicated that there is asymmetry in the farm-retail level price transmission for the dairy sector. The effect of an increase in farm price of milk affects the retail price of dairy products more rapidly, compared with a decline in the farm level price of milk. Because of the slow response of the retail market to farm price decline, there is the general belief that consumers do not benefit from decreases in milk prices, although this decrease is usually passed on to consumers.

(30) Kotler, Philip. "Price Decisions," Marketing Management. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1967.

Following a brief history of the changing role of pricing in a total marketing program, Kotler discusses the economic theory of setting prices and its limitations. He develops a theoretical pricing model consisting of demand, cost, revenue, and profit functions which he solves for the profit-maximizing price. The restrictive assumptions which limit this model's applicability to practical pricing problems are outlined, leading to a discussion of price setting in practice. Practical price-setting methods are divided into three main categories: cost-oriented pricing (markup pricing and target pricing), demand-oriented pricing (price discrimination on the basis of product, customer, place, or time), and competitive-oriented pricing (going-rate pricing, and sealed-bid pricing). Kotler notes that any model which ignores demand elasticities in setting price is not likely to lead to maximum profits in the short or the long run; however, he does derive the special conditions under which a rigid markup would lead to profit maximization. The pros, cons, and uses of each method are addressed in turn. Kotler also devotes one section of the chapter to estimating the reaction of buyers (attitude surveys, market tests, and statistical analysis) and competitors. Finally, product-line pricing methods where demand and cost of products are interrelated are discussed.

(31) Lamm, R. McFall, and Paul C. Westcott. "The Effect of Changing Input Costs on Food Prices," American Journal of Agricultural Economics. Vol. 63, 1981, pp. 187-96.

Lamm and Westcott use an extension of Popkin's stage of processing model to analyze the relationship between changes in factor prices and changes in retail prices in an attempt to explain why food prices increase faster than nonfood prices and what effect changes in raw input and nonfarm food input prices have on consumers. In the theoretical model, retail prices are determined by a general markup process where current output price is jointly determined by expectations, current input prices, lagged output prices,

and prices of substitutes and complements. It is noted that the inclusion of the prices of close substitutes implies a simultaneous structure and that the causal path between output and input prices is unidirectional, with input price determining output price. For empirical implementation, the model was assumed to be linear, 15 Bureau of Labor Statistics food groups were considered, and the dependent variables were expressed as quarterly percentage changes. The complete model (17 behavioral equations and 3 aggregation equations) was estimated using 3 stage least squares. The maximum lag length was found to be one quarter, implying that increases in input prices and changes in expectations and demand shifters have an almost immediate affect on retail food prices. Sim's causality tests supported the underlying assumption that farm prices cause retail prices. Results were found to be consistent with Heien's (25) results, using monthly data and supporting the use of a markup-pricing model representation of the food price determination process. In summary, Lamm and Westcott emphasize the two most important findings: (1) changes in the lag structure in the food industry are relatively simple with most of the effect of changing resource prices passed to the retail level within two quarters, and (2) changes in nonfarm factor prices are important and even dominant in the food price determination process.

(32) Lopez, Ramon E. "Analysis of a Small Open Economy: The Case of Energy Prices in Canada," American Journal of Agricultural Economics. Vol. 64, 1982, pp. 510-19.

This article focuses on the longrun comparative statics of the effects of factor price changes in an increasing-cost industry. In particular, the longrun effects of increasing energy prices on land prices, average farm size, energy demand, and industry output are analyzed for an increasing-cost industry composed of identical firms. Lopez describes two approaches to longrun studies of competitive industries: (1) comparative statics of the firm in a competitive industry with implications for industry supply and demand responses via aggregation across firms (Silberberg (86), Ferguson and Saving (67), Bassett and Borcherding (53)), and (2) comparative statics of industry under specific assumptions about aggregate industry technology without explicit consideration of the firm's technology or changes in the number of firms (Floyd (68), Gardner (22)). Lopez follows the first approach (offering a critical appraisal of the second) but, in contrast to previous studies, considers an increasing-cost industry. A five-equation recursive model is constructed to analyze the effect of energy price changes on the following endogenous variables: land rental prices, average farm size in acres, number of farms in the industry, industry output supply, and industry energy demand. Differentiation of the various equations and algebraic manipulation yields expressions for the longrun elasticities of each of the endogenous variables with respect to energy prices as a function of the elasticity of substitution between land and energy, output elasticities of demand for energy and land, shortrun, own-demand elasticities for land and energy, shortrun, own-price output elasticity, shares of energy and land rental values in total sales, and the aggregate supply elasticity of land. The necessary and sufficient conditions for expecting increases in average farm size, decreases in industry output, and decreases in number of farms when energy prices increase are discussed. The expressions are then applied to calculate the longrun Canadian agricultural response to domestic increases in energy prices. Conclusions of the study are: (1) the longrun effect of an increase in an exogenous factor price on the price of the factor with a rising supply curve is nonpositive, (2) in contrast with a constant-cost industry, the aggregate factor demand of an increasing-cost industry is not necessarily downward sloping (downward sloping if elasticity of substitution between that factor and factor with rising curve is nonnegative), and (3) longrun equilibrium output does not necessarily vary inversely with factor price even if the increasing price factor is not inferior. The second and third results indicate that the Bassett and Borcherding (54), and Ferguson and Saving (67) theorems (that is, longrun factor demand curves are always downward sloping, and industry output in the long run always varies inversely with factor price) are not universally true, but valid only for constant-cost industries.

(33) Lopez, Ramon E. "Estimating Substitution and Expansion Effects Using a Profit Function Framework," American Journal of Agricultural Economics. Vol. 66, 1984, pp. 358-67.

Lopez presents a procedure for measuring the net substitution and expansion effects from a profit function framework rather than from the cost or revenue function. Thus, Lopez enhances the empirical usefulness of the profit function approach by demonstrating that the same information from other, more direct approaches can be obtained from the profit function without the econometric problems. To determine the relationship between the profit function and the other approaches, the profit function is first defined in

three equivalent fashions. These yield the Marshallian (75) output supply and input demand functions, the constant-output input demand functions (Hicksian), and the constant-input output supply functions. The Hicksian demand functions reflect movement along an isoquant for a given output, while the compensated output functions reflect movement along a production possibilities frontier for constant input levels. To relate these measures, Lopez expresses the second derivatives of the cost and revenue functions in terms of the profit function. He arrives at four equations which allow for the separation of substitution and scale effects using estimates of the total effect provided by the factor demand and output supply equations derived from the profit functions.

(34) Lopez, Ramon E. "Measuring Oligopoly Power and Production Responses of the Canadian Food Processing Industry," Journal of Agricultural Economics. Vol. 35, 1984, pp. 219-30.

The food-processing industry in Canada is a major sector in the entire economy. Since it is a highly concentrated sector, this study developed a model which allowed for noncompetitive behavior and permitted measurement of the degree of market power in the industry. Empirical estimation of the model indicated that the hypothesis of price-taking behavior was rejected and there was a slight increase in the average degree of oligopoly power in the industry during the period covered by the sample data. The most responsive inputs to changes in the price structure in the industry were labor and energy, while raw food materials and capital were less sensitive to these changes. Moreover, energy and labor were very strong substitutes, while energy and capital were complements.

(35) Lopez, Ramon E. "Supply Response and Investment in the Canadian Food Processing Industry," American Journal of Agricultural Economics. Vol. 67, 1985, pp. 40-8.

Lopez estimates a set of aggregate output supply, factor demand and investment equations for the Canadian food-processing industry, using an intertemporal profit-maximizing model. Annual data for the 1961-79 period and a normalized quadratic profit function were used in estimation. This approach allows the measurement of output supply and input demand elasticities throughout the adjustment path. Short, intermediate, and longrun elasticities were calculated. All own-price elasticities were found to have the expected signs and were inelastic, even in the long run. Capital adjustment costs were found to have a substantial effect on shortrun and intermediate-run responses. The hypothesis of instantaneous adjustment was rejected. Adjustment of capital stocks to optimal levels was found to take over 2 years and thus capital stocks should not be regarded as fixed. Some interesting results with respect to individual elasticities are as follows: (1) labor was found to be a substitute for capital and energy a complement, (2) labor and energy elasticities indicate a gross complementary relationship in the short run, but strong gross substitutability is evidenced in the long run, (3) raw food prices had the largest negative effect on output supply, (4) the wage rate was found to have a positive effect on output indicating inferiority; however, this coefficient estimate was not significant.

(36) Lutton, Thomas J., Lloyd D. Tiegen, and Richard Haidacher. "A Comparative Statics Analysis of Value-Added and Marketing Margins in the Food System." Working paper. U.S. Dept. Agr., Econ. Res. Serv., Mar. 1982.

In this paper, demand, value-added, and profit functions are integrated to provide a conceptual framework for comparative statics analysis of the effects of shifts in retail food demand on retail and farm quantities and prices. The longrun equilibrium assumptions of the Brandow (3), Floyd (68), and Gardner (22) models are relaxed by including quasi-fixed factors of production. In addition, the analysis is extended to the n-factor case to allow for input complementarity as well as substitutability. The resulting model consists of four equations: an aggregate consumer demand equation derived from the indirect utility function, and retail supply and farm level demand equations derived from the profit function. The authors note differences between the value-added approach and the traditional USDA marketing-margin approach, namely, the value-added system can determine the effect of an exogenous retail demand shift on output price, output, demand for the farm product, farm price, and value added, whereas the traditional USDA approach assumes no change in output or input demand with an exogenous demand shift. Since perfectly inelastic output supply and derived input demand functions are unlikely, the authors assert that the USDA's marketing margin probably measures something other than the value added in the food-processing

and distribution sector. Results from this paper suggest that if longrun equilibrium assumptions are relaxed, an increase in the demand for food may have the opposite effect on the price spread than that envisioned by Gardner (22). Thus, events increasing the supply of one type of farm product may decrease the overall farm-retail price spread in shortrun equilibrium, and an increase in the demand for food may increase the marketing margin if marketing inputs are perfectly inelastic.

(37) Miedema, Allen K. "The Retail-Farm Price Ratio, the Farmer's Share and Technical Change," American Journal of Agricultural Economics. Vol. 58, 1976, pp. 750-56.

In this article, work by Gardner (22) and Muth (81) is synthesized to develop a more complete specification of the effects of technical change, which allows for less than perfectly elastic product demand and factor supply elasticities. Miedema first reviews both the Gardner and Muth models. Gardner's results are reproduced and extended using Muth's formulation which contains two additional parameters to allow for neutral- and factor-biased technical change. The final model is then used empirically to predict the effect of technical change on the food marketing industry, in particular the effect on the retail/farm price ratio and on factor shares. Principal findings are the following: (1) in general, both extremely limited substitutability between agricultural commodities and marketing inputs and an inelastic retail demand are necessary conditions for the retail/farm price ratio to increase in the presence of neutral technological change, (2) technical change that is marketing-input-saving will decrease the ratio, and (3) no general statement can be made about the effect of technical change (either neutral or factor biased) on factor shares. The outcome is dependent on the elasticities of supply and demand, the elasticity of substitution, and the initial factor shares.

(38) Ogren, Kenneth, E. "The Farmer's Share: Three Measurements," Agricultural Economics Research. Vol. 8, 1956, pp. 43-50.

USDA uses the market basket series to calculate the farmer's share of the retail food dollar. Retail cost and farm value are computed for a fixed quantity of food products. Thus, the marketing margin derived from this series reflects changes in the cost of a fixed quantity of marketing services. While convenient and easy to calculate, the farmer's share measured with this series applies only to consumer food dollars spent in retail stores. Two alternative measures are proposed: an aggregate food expenditures approach based on the marketing bill series and a value-added approach, both of which include food sold through channels other than retail stores (for example, restaurant meals and producer-wholesale level purchases). The marketing margins derived from these series reflect the effects of changes in volume, unit marketing costs, and marketing services provided (for example, the demand for increased processing). The farmer's share from total consumer expenditures for food products and from the value-added approach have decreased relative to the farmer's share for the market basket of food products. This is attributed to the increased importance of consumer purchases through marketing channels which provide more services at higher per-unit costs. In summary, it is noted that the market basket approach fails to reflect the following: (1) the shift between market channels, (2) the changes in kinds of food purchased and the changes in marketing services associated with these shifts, and (3) the growing importance of the urban population, which requires increased transportation and other services. The other approaches capture these changes; however, they are based on inadequate data. The value-added measure is conceptually, the most satisfactory but it can be applied only at the total industry level.

(39) Oxenfeldt, Alfred R. "Decisions About Price" and "The Administration of Pricing," Executive Action in Marketing. Chapters 9 and 10. Belmont, CA: Wadsworth Publishing Co., 1966.

In chapter 9, three fundamental approaches to pricing are described and critiqued: (1) the accounting, or cost-oriented approach (cost-plus pricing), (2) the economist's approach (profit maximization with marginal cost equaling marginal revenue), and (3) the marketing specialist approach (cost-plus pricing, used with reservations, since reliable data for the economist's approach are not available). These approaches are said to stem from two bodies of theory (decision theory and price theory) and applications of each to price setting are discussed. In presenting the factors of price theory relevant to executives, Oxenfeldt outlines the relationships of each market participant (individuals within a firm, customers, rival sellers, intermediaries, suppliers, and government) to pricing. This is followed by a brief description of the

following market structure models: purely competitive, heterogeneous oligopoly, and homogeneous oligopoly. Finally, the criteria of a good price are discussed, and an arithmetic example of pricing, setting marginal cost equal to marginal revenue, is given. Chapter 10 focuses on actual business practices. First, the organization, personnel, information, and research needed for effective pricing are briefly discussed. Attention is then centered on specific pricing methods. These methods fall into three broad categories: (1) complete pricing methods (cost plus, flexible markup, trial and error, research method, and intuitive method), (2) partial pricing methods (price maintenance or price followership), and (3) price-line pricing (maintaining constant price over long periods of time, while quality changes reflect the changes in costs). The limitations to these methods are considered to be the following: they are based on cost and ignore demand considerations, marginal cost should be considered rather than total cost, and goals other than shortrun profit maximization should be considered. A multistage approach which overcomes the above limitations is suggested and outlined. Finally, pricing strategies for particular situations (for example, the pricing of a new product or pricing in a declining market) and a fairly complex pricing example are presented.

(40) Parish, R.M. "Price 'Levelling' and 'Averaging'," Farm Economist. Vol. 11. 1967, pp. 187-98.

Various theories of the economic rationale and consequences of price leveling and averaging have been proposed and debated. Parish reviews and elaborates on some of these explanations and analyses. A number of interesting questions are explored. Are leveling and averaging distinct phenomena or is one a consequence of the other? Do the terms leveling and averaging connote the existence of a negative correlation between margin and price level because of the reluctance of retailers to change retail price in response to farm price changes? Are leveling and averaging statistical illusions due to inadequate data? Assuming that they are real phenomena and arise from a reluctance of retailers to change retail prices, Parish offers several explanations of why retailers adopt these practices. The first two explanations are in terms of cost conditions: (1) there are costs associated with changes in price, thus a reluctance to change, and (2) with sharp increases in average unit costs and variations in sales, retailers can gain by using leveling to stabilize the quantity sold. The other explanations center on asymmetrical demand responses: (1) margins vary inversely with the price level due to demand being more elastic at high prices than at low prices, and (2) consumers behave differently to price increases and decreases; they are more price conscious when the price is high and, therefore, more easily lost when the price increases. Parish also suggests that leveling and averaging may be instances of leader-pricing, since all three give rise to similar margin differences among products. A graphical analysis of the economic effects of leveling is also presented. Parish shows that leveling leads to greater stability in quantity sold and in retail prices; however, farm prices are destabilized. The extent to which stabilization of retail prices and destablization of farm prices occurs is dependent on the elasticity of farm supply. The discussion of economic effects gives rise to welfare considerations. Economists criticize leveling and averaging on the grounds that: (1) they distort price relationships and, therefore, lead to a loss in economic efficiency, and (2) greater stability in retail prices hurts the poorest consumers. Counterarguments are mainly concerned with the psychic benefits to consumers of more stable prices, for example, retailers are actually providing a service to consumers by not passing on transitory price changes (most farm price changes are regarded as transitory). However, Parish notes that it is often the case that these farm level price changes are not simply transitory, but seasonal in nature, and a failure to reflect these changes at the retail level constitutes a pricing distortion. Although Parish stresses that the destabilizing effect on farm prices can outweigh benefits to consumers from price leveling and averaging, he concludes that, in general, their overall effect may be positive.

(41) Shepherd, G.S. Marketing Farm Products - Economic Analysis. Chapter 19. Fourth edition. Ames: Iowa State Univ. Press, 1962.

This chapter addresses misconceptions concerning the marketing system and the farmer's share of the food dollar. In particular, the significance of wide versus narrow marketing margins, the number of intermediaries, high marketing costs, and intermediary profits, as they relate to the concept of market efficiency, are discussed. Margin characteristics are noted (its stability in comparison with retail price, its sluggish nature, its variation according to product type) and their implications for farm price discussed. Although wide marketing margins, large numbers of intermediaries, high marketing costs and high

intermediary profits do not necessarily imply market inefficiency, Shephard concludes that reductions in marketing costs could have a substantial effect on margins and farm and retail prices.

(42) Thomsen, F.L. Agricultural Marketing. Chapters 9 and 11. NY: McGraw-Hill Book Co. Inc., 1951.

In Chapter 9, Thomsen presents the concept of derived demand. Differences between consumer demand and derived demand, as well as similarities, are outlined. Farm price determination is discussed and a graphical illustration provided. Margins are defined as prices paid for services rendered by marketing agencies, and the prices paid for these services are determined by the interaction of their supply and demand. Thomsen argues that, since neither the prices paid by consumers for a given quantity nor the quantity sold is determined by intermediaries, it follows that, except for short periods of time and through the feedback from farm price, these intermediaries do not substantially affect retail price. He notes that although retail food prices as a whole may be determined under competitive conditions, marketing margins are more often determined under imperfect competition. Thus, a review of the differences between perfect and imperfect competition is presented. In particular, the factors that enable a seller to control prices (product differentiation, locational advantages, and restraints on trade) are discussed with respect to their effects on the marketing margin. Chapter 11 deals solely with marketing margins, costs, and the factors affecting them. Terminology for marketing margins (absolute, percentages and markup margins, price spread, marketing costs, marketing charges, and breakdown of consumer dollar) are defined and general misuses of the terms discussed. Thomsen presents advantages and defects of three methods of computing marketing margins: (1) tracing a specific truckload of a commodity through the system, (2) comparing prices at different levels of the marketing channel, and (3) obtaining data representing gross dollar sales and purchases by each type of marketing agency and the number of units handled in order to calculate the gross margin. Trends in the marketing bill, marketing margins, marketing costs, the relative importance of each component of the marketing channel to the overall margin, and the breakdown of the consumer food dollar were reviewed. Individual commodity margins were also analyzed and the following generalizations made: (1) the farmer's share and the margin vary widely among commodities, (2) the marketing margin is relatively large and the farmer's share small for commodities undergoing elaborate processing, and (3) the more perishable the commodity, the greater the intermediary share and the smaller the farmer share. Finally, fallacies that have arisen from a misunderstanding of the marketing margin, its determinants, and its relationship to retail and farm prices are discussed throughout the chapter.

(43) Thomsen, Frederick L., and Richard J. Foote. Agricultural Prices. New York: McGraw-Hill, 1952, pp. 51-54.

Differences between the derived demand for farm products and retail demand are attributed to three main factors: (1) derived demand equals retail demand minus a schedule of marketing charges, (2) derived demand reflects the differing seasonality of production and consumption of storable products which fluctuate even with no change in retail demand, and (3) wholesalers anticipate changes in retail demand. Discussion of the first factor includes the cases of flat rate, constant percentage, and combination margins as well as their implications for the elasticities. Four types of derived demand are noted: (1) derived demand in a wholesale or farm market for a commodity that does not change form, (2) derived demand for commodities used in processing, (3) derived demand for products used by farmers, and (4) derived demand for productive inputs (land, labor, capital). However, a discussion of the implications with respect to marketing margins or retail demand does not ensue.

(44) Tomek, William G., and Kenneth L. Robinson. "Marketing Margins for Farm Products," Agricultural Product Prices. Chapter 6. Second edition. Ithaca, NY: Cornell Univ. Press, 1981.

Tomek and Robinson begin this chapter by discussing alternative definitions of marketing margins and the notion of derived demand. The assumption of fixed proportions is maintained throughout the chapter. The manner in which margins vary with the volume of the commodity produced is investigated and related to the elasticity of supply of marketing services. Empirical measures of the marketing margin reported by USDA (the farm-retail price spread for individual foods, the food marketing bill, and the farmer's share of the consumer dollar) are discussed along with the common misuses of these statistics. Factors affecting the margin (shifts in derived demand and supply curves or in retail demand due to changes in factor prices,

and efficiency or services embodied in farm products) are presented. Changes in the margin are divided into two parts (changes due to the introduction of new services and changes related to existing services) with differing effects on retail and farm prices. Derived demand, it is noted, is affected not only by changes in retail demand, but by changes in the marketing margin as well. Finally, Tomek and Robinson relax the assumption of perfect competition. Results from studies of market structure in the food industry are summarized and conclusions drawn about the relationships between market structure and the marketing margins for food.

(45) Waldorf, William H. "The Demand for and Supply of Food Marketing Services: An Aggregate View," Journal of Farm Economics. Vol. 48, 1966, pp. 42-60.

The objective of this article is to explain the decrease in the farm share of U.S. consumer food expenditures. Previous researchers explained the decrease in farm share in terms of a larger income elasticity for marketing services than for farm products. In this article, Waldorf attempts to measure the elasticity of the demand for marketing services by estimating the demand for and supply of food-marketing services. The demand for marketing services was estimated by applying both OLS and 2SLS to a double-log model, with per capita consumption of farm food-marketing services as the dependent variable and an index of prices of marketing services deflated by an index of other consumer prices, real per capita disposable income and a time trend as independent variables. Waldorf views the most significant deficiency of this specification as the omission of a variable measuring the opportunity cost of a wife's time. Along with estimating the demand for farm food-marketing services, two other demand relations were estimated: the demand for farm food products and the demand for food at the retail level. With respect to the demand for marketing services, income elasticities were found to be significantly less than unity and unaffected by the method of estimation. Price elasticities, on the other hand, were affected by the estimation method. Income elasticity estimates from the three demand relations supported the notion that the income elasticity for food at the retail level is a weighted sum of the income elasticities for farm products and marketing services, with the weights being the farm and marketing shares. Assuming a Cobb-Douglas production function for the farm food-marketing sector and neutral technological change, Waldorf derives the industry marginal cost function and proceeds to estimate the supply function for marketing services. Future work in finding a satisfactory lag model is suggested. In conclusion, some of Waldorf's findings are: (1) nearly all of the increase in household purchases of farm food-marketing services between 1929 and 1962 resulted from an increase in demand, (2) the aggregate demand for marketing services increased 2 to 3 times as fast as the demand for farm food products, and (3) the supply function of marketing services was found to be elastic, contributing to a stable real price during the period analyzed. The price and quantity series for marketing services used by Waldorf differ conceptually from those used by other researchers.

(46) Ward, Ronald W. "Asymmetry in Retail, Wholesale, and Shipping Point Pricing for Fresh Vegetables," American Journal of Agricultural Economics. Vol. 64, 1982, pp. 205-12.

Ward measures the linkages between retail, wholesale, and shipping-point prices for fresh vegetables. A price-linkage model is developed using Wolffram's asymmetry procedure with a distributed lag model. Empirical analysis (price transmission measurement) is limited to a subset of fresh vegetables where price information is available at each point of exchange. Due to seasonality, gaps appear in the data series; therefore, dummy variables are used so that the distributed lag model reflects whether or not lagged information exists at that period. Although most studies point to a causal link from shipping-point to wholesale to retail prices, actual leads and lags will depend on how quickly a particular market assimilates market signals. Thus, Ward notes, the existence of leads and lags is ultimately an empirical question. Granger causality tests were conducted to determine leads or lags and it was found that while retail prices lag wholesale prices, wholesale prices lead shipping-point prices. Several explanations were offered (such as wholesale markets are more concentrated and, therefore, information is readily assimilated). Based on these results, a lead linkage from wholesale to both retail and shipping point is assumed throughout the analysis. Estimation results indicate that significant asymmetry holds for the majority of products studied. Price increases at the wholesale level are not totally reflected at retail, while consumers can expect to benefit immediately from price decreases. Reasons for the retail resistance to increased prices may be related to the perishability of the product or to an oligopolistic market. Asymmetry is also present in the

wholesale-shipping-point relationship. Ward notes that these asymmetric results suggest a deviation from the traditional concept of constant percentage markup.

(47) Waugh, Frederick V. Demand and Price Analysis. TB-1316. U.S. Dept. Agr., Econ. Res. Serv., 1964, pp. 19-27, and 78.

There are two conflicting notions of the retail-derived demand relationship. Waugh describes one as a shortrun situation (farm price plus a marketing margin determines retail price) and the other as long run in nature (retail price minus a marketing margin determines farm price). Using the latter notion, the effects of a constant percentage and a constant absolute margin are discussed. Waugh shows that a constant-percentage margin implies that price flexibilities are the same at farm and retail, and a constant-absolute margin implies that price is more flexible at the farm level than at the retail level. Mathematical proof is provided assuming fixed farm input/output proportions. Price- and quantity-dependent demand equations were estimated using annual data, a double-log specification, and the following price series: retail price index, retail price of market basket, farm price of market basket, and the farm-retail price spread. Results indicate a change in the price spread from a predominately constant-absolute margin prior to 1941 to a constant-percentage margin after 1946. In addition, while rising income increased retail price substantially, it had little influence on farm price. This was attributed to the concomitant rise in wages, which constituted a large part of both the price spread and consumer income. Thus, the advantage of rising income at the farm level was mitigated by widening margins.

(48) Wohlgenant, Michael K. "The Retail-Farm Price Ratio in a Competitive Food Industry with Several Marketing Inputs." Faculty Working Paper No. 12, Raleigh, NC: North Carolina State Univ., 1982.

In this paper, Gardner's (22) two-input, single-output model, which predicts changes in the retail-farm price ratio to exogenous shifts in demand and input supplies, is generalized to more than two inputs. Results are obtained for the general n-input case. The implications of three special cases are examined: (1) when only the farm input is specific to the industry, (2) when there are three rather than two inputs, and (3) when the farm input is weakly separable from each marketing input. While results are shown to be generally consistent with Gardner's, they yield additional insight into the nature of changes in the price ratio when there are relative price changes within a set of marketing inputs, for example, a change in transportation or packaging input prices relative to the wage rate. Results from the first case indicate that when the substitution between farm and nonfarm inputs is less (larger) than the scale effect, the relative change in the price ratio from a change in the price of one marketing input is greater (less) than the share of that input. Thus, the effect of a marketing input price change may not be well approximated by its input share as is typically believed. For the three-input case, Wohlgenant discusses specific results and relates them to Gardner's results; however, in general, the change in relative marketing input prices (and thus the retail/farm price ratio) depends on the relative supply elasticities and the degree of input substitution. In the third case, Wohlgenant shows that the Divisia index is the appropriate one for aggregating input prices when there is nonzero substitution. In conclusion, it is noted that the model could be extended to look at the effect on the farmer's share of the retail dollar, or modified to incorporate the effects of technical change, thereby generalizing Miedema's (37) results for the two-input case.

(49) Wohlgenant, Michael K. "Competitive Storage, Rational Expectations, and Short-Run Food Price Determination," American Journal of Agricultural Economics. Vol. 67, 1985, pp. 739-48.

This article uses the rational expectations framework to derive testable implications of the role of inventories on the relationship between retail and wholesale food prices. The theoretical model indicates that the standard markup pricing model is misspecified and should be expanded to include a Jorgenson-type user cost variable, which depends on expected future wholesale price. The price expectations model is derived through rational expectations. Therefore, the retail price specification depends on the stochastic process generating expected wholesale price, which consists of at least current and lagged wholesale prices. The econometric specification is applied to monthly price relationships for beef. The results are found to be consistent with the theory and to indicate rejection of the standard markup model.

(50) Wohlgenant, Michael K. "Demand for Farm Output in a Complete System of Demand Functions," American Journal of Agricultural Economics. Vol. 71, 1989, pp. 241-52.

Demand interrelationships for farm outputs that are theoretically consistent with consumer demand and marketing-group behavior are developed and applied econometrically to a set of eight disaggregated food commodities. The conceptual model is derived from reduced-form specifications for retail farm prices. This approach circumvents the need for retail quantities, which are often not available for disaggregated food commodities. The results are consistent with the theory that suggests consistency with competitive behavior and constant returns to scale technologies in food processing. The results also generally indicate significant input substitution between farm and marketing inputs. Except for poultry, derived-demand elasticities are found to be 40 percent larger than those derived assuming fixed-factor proportions.

(51) Wohlgenant, Michael K., and John D. Mullen. "Modeling the Farm-Retail Price Spread for Beef," Western Journal of Agricultural Economics. Vol. 12, 1987, pp. 119-25.

The usual approach in modeling farm-retail price spread behavior is to use a combination of both absolute and percentage amounts of price spread. One limitation of this method is that the relationship between farm level and retail market price can be accurately described only if changes do not occur in both retail demand and output supply of the good. This article presents a new model, applied to beef, which incorporates changes in both farm supply and retail demand. An empirical estimation of this model is undertaken using non-nested testing procedures. Results indicate that the markup pricing model is inferior to the relative price spread specification. Despite the differences in performance of these models, both yield the same derived-demand elasticities at the sample means.

Section II: Theory of Derived Demand

(52) Allen, R.G.D. Mathematical Analysis for Economists. NY: St. Martin's Press, 1938, pp. 369-74 and 502-09.

Allen derives the elasticity of demand for a factor of production, assuming a linear homogeneous production function and perfectly competitive input and output markets. The formulas for the elasticities indicate that there are two forces at work: (1) an increase in price leads to a decrease in demand through a reduction in industry output, and (2) an increase in price leads to a substitution of other factors for the factor in question, holding output constant. Allen's formula differs from that of Hicks (74). Allen assumes the supply of other factors is perfectly elastic. Allen also develops the more general n-factor case and, in so doing, the partial elasticity of substitution (Allen elasticity of substitution) is defined. The Allen elasticity can be positive or negative; however, it is shown that the n-1 partial elasticities of substitution between one factor and the others cannot all be negative. In addition to the interpretations given for the two-input case, it is now evident that the effect of a change in the price of one factor on the demand for another factor depends on whether the inputs are competitive (Allen elasticity positive) or complementary (Allen elasticity negative).

(53) Bassett, Lowell R., and Thomas E. Borcherding. "Industry Factor Demand," Western Economics Journal. Vol. 8, 1970, pp. 259-61.

Two common methods of going from factor demands at the firm level to those at industry level are reviewed and critiqued. It is argued that the first method, simple aggregation, is not rigorous since positively sloped factor demands are a possibility at the firm level. The second method assumes a linear homogeneous production function. However, this method creates difficulties with the definition and interpretation of equilibrium conditions for individual firms. This article proposes an alternative derivation of factor demand at the industry level which avoids these pitfalls. The derivation starts with an industry in longrun equilibrium and considers the effect of an increase in price of a factor on the new equilibrium. The slope of the firm's demand curve, with output price adjusting, is unambiguously negative only if either: (1) all firms are identical (that is, they have the same input/output ratio), or (2) the input/output ratio that pertains to the marginal firm is representative of the industry.

(54) Bassett, Lowell R., and Thomas E. Borcherding. "The Firm, the Industry, and the Long-Run Demand for Factors of Production," Canadian Journal of Economics. Vol. 3, 1970, pp. 140-44.

Factor demand schedules for the profit-maximizing competitive firm are normally considered to be negatively sloped. However, this result is dependent on the assumption of constant prices, both output price and other input prices. The longrun factor demands, when output price is allowed to vary, are shown to be unambiguously negatively sloped only for inferior factors. In addition, without the standard assumptions for a competitive industry (a linear homogeneous aggregate production function), one cannot state conclusively that industry factor demand is negatively sloped.

(55) Bassett, Lowell R., and Thomas E. Borcherding. "The Relationship Between Firm Size and Factor Price," Quarterly Journal of Economics. Vol. 84, 1970, pp. 518-22.

In this article, a relationship between the slope of a firm's expansion path and the direction of change in output in response to a change in a factor price is demonstrated. Five cases are considered: (1) constant-input ratio, (2) input ratio varies directly with output, (3) input ratio varies indirectly with output, (4) first factor is inferior and condition 2 holds, and (5) second factor is inferior and condition 3 holds. The key to the relationship lies in the shifts of average costs and marginal costs in response to a change in price of the factor. In particular, if average costs increase more than marginal costs due to an increase in price, then output will increase; if average costs increase less than marginal costs, output will decrease ; and if the changes in average and marginal costs are equal, there is no change in output. The sign of the slope of the expansion path is shown to depend on whether the factor is normal or inferior. If the factor is inferior (case 4), an increase in price results in an increase in output; however, if the factor is normal (cases 1, 2, 3, 5), the effect on output is ambiguous. Case 1 is that of a homothetic production function where output is invariant to changes in factor prices. Using this as a benchmark, cases 2, 3, and 5 are examined. As the expansion path rotates away from the axis in question, the slope of the expansion path decreases. The implications are the following: output increases as price increases for case 2, and output declines as price increases for cases 3 and 5. Thus, given the slope of the expansion path, one can predict how firm size varies with a change in any factor price.

(56) Bear, D.V.T. "Inferior Inputs and the Theory of the Firm," Journal of Political Economy. Vol. 73, 1965, pp. 287-89.

Assuming a firm that produces output according to a strictly concave production function, operates in competitive markets, and maximizes shortrun net returns, Bear demonstrates that the usual assumption of an increase in input price leading to a decrease in output is true only if inferior inputs are excluded. On a priori grounds, there is no reason to rule out the possibility of inferior factors, that is, the existence of inferior factors is a matter for empirical investigation. Consequently, the choice of functional form is crucial since certain functional forms preclude the existence of inferior factors. Bear proves that in the case of a homogeneous production function, no factor is inferior. Finally, he notes that, generally, a factor cannot be inferior at all output levels. It should be recalled that this is a shortrun analysis. In the long run, an increase in output can result from the increase in the price of a normal input due to changes in the equilibrium output price.

(57) Braulke, Michael. "The Firm in the Short-Run Industry Equilibrium: Comment," American Economic Review. Vol. 74, 1984, pp. 750-53.

The article is a generalization of Ronald Heiner's (71) study. It is generally accepted that the traditional law of supply and demand will not be valid if an individual competitive firm is considered within the general framework of the industry where it belongs. Under the special condition of an infinitely elastic supply in all factor markets, Heiner showed that at least the law of demand will hold in the short run for the entire industry, if the demand for its output can be represented as a downward-sloping schedule. Using Heiner's basic theoretical framework, Braulke extended Heiner's findings by showing that Heiner's theoretical results still apply if the industry also faces a less than infinitely elastic, but normal, supply for some of its input markets.

(58) Braulke, Michael. "On the Comparative Statics of a Competitive Industry," American Economic Review. Vol. 77, 1987, pp. 479-85.

The major point of this article is that under the conditions of a negatively sloped output demand and positively sloped input supply and the absence of a sufficiently weak cross-price relationship, the basic law of supply and demand will hold for aggregate output demand and input demand behavior of a competitive multi product industry in both the long run and short run. This is true not only for firms with similar characteristics but also for firms which are widely diverse from each other. Results also show that the entry and exit process guarantees that net addition to industry supply and demand must be non-negatively correlated with changes in longrun equilibrium prices.

(59) Bronfenbrenner, M. "Notes on the Elasticity of Derived Demand," Oxford Economic Papers. Vol. 13, 1961, pp. 254-61

Three standard formulas for the elasticity of derived demand are reconciled and compared. The Hicks (74) formula is the most general and the only one permitting a test of all four of Marshall's (75) laws. The Marshall and Allen (52) formulas are special cases of the Hicks equation where elasticity of substitution is zero and supply of other factors is infinitely elastic. It is shown that Marshall's third law (the importance of being unimportant) is not universally true, regardless of the formula used. Bronfenbrenner considers the third law to be an acceptable approximation to shortrun conditions: elasticity of substitution is low and supply elasticity is positive. However, he feels the importance of this law pales in comparison with the role of the input cost share in determining the relative importance of elasticity of demand and elasticity of substitution in computing derived-demand elasticity. Although both Hicks and Robertson have tried to intuitively explain the exceptional case, Bronfenbrenner concludes, "The plausibility of the exception to Marshall's third law has yet to be demonstrated convincingly or even completely in literary terms." Additionally, Bronfenbrenner makes the following observations: (1) although Hicks extends Marshall's analysis by relaxing the assumption of fixed proportions, he limits himself to cases of longrun competitive equilibrium where the production function is linearly homogeneous whereas Marshall does not, (2) the Marshall and Hicks formulas deal with market demand whereas the Allen model is of individual firm level demand, (3) the Allen formula is applicable to the competitive industry if the other factor is unspecialized to it, (4) the Allen formula has the advantage of permitting a literary translation and showing clearly the importance of cost share in determining the weight of elasticities of demand and substitution, (5) supply schedules to firms and industry are often positive and elastic enough to make the Allen expression a good representation of reality, and (6) Hicks requires other factor prices to vary, with output price constant, in order to maintain longrun equilibrium whereas Allen holds other input prices constant and allows output price to make adjustments to maintain longrun equilibrium.

(60) Bruno, Michael. "Duality, Intermediate Inputs and Value-Added," Frontiers in Quantitative Economics. M. Fuss and D. McFadden (eds.). Amsterdam: North-Holland Publishing Co., 1978.

In an extension of duality theory, Bruno develops the concept of value added as a sort of restricted profit function in which certain primal variables (quantities) are replaced by their duals (prices). A nominal value-added function is first defined and its properties, analogous to those of the dual profit function, are outlined. Following this introduction to value-added functions, the duality between the profit and production function is used to analyze double-deflated, value-added (DVA) functions. Value added in constant prices is considered using two procedures: deflating by a single output price (single value added, SVA) and a double deflated procedure which measures real value added in base-year prices (double value added, (DVA)). The DVA model is the reference point for the analysis of biases that result when DVA production functions are used as substitutes for the true gross output relationships. Bruno summarizes his results in the following theorem which holds regardless of the homogeneity properties of the production function. DVA functions lead to derived value-added production functions whose partial derivatives correctly measure the marginal productivities of the primary factors if each intermediate input satisfies one of three conditions: (1) these inputs are used in fixed proportions to output, (2) relative prices of intermediate inputs remain constant, (3) the original gross-output production is functional separable into the intermediate and all primary inputs. In the case of separability, he states that double deflation can be interpreted as a simple Divisia index. Bruno notes that although SVA functions are free of bias even

without these assumptions the DVA approach is useful in certain instances, for example, the measurement of real, total factor productivity. In the measurement of residual total productivity, the effect of intermediate inputs is usually ignored. Comparisons of the SVA and DVA approaches allow for estimation of the bias introduced by leaving out intermediate inputs. Bruno shows that the measurement of total productivity change, from constant price value-added figure, will be unbiased if each intermediate input left out is either used in fixed proportions or else a Divisia (shifting weight) index is used to obtain the constant-price value-added figures from the underlying intermediate input and gross output figures. He then calculates the bias in the case of both single-output price deflation and double deflation with constant base-year weights. When base-weight DVA functions are used to measure growth in total productivity, separability is no longer sufficient to eliminate the bias. Finally, Bruno gives a brief description of how the value-added-function approach could be extended to the case of imperfect competition.

(61) Cowling, Keith, and Michael Waterson. "Price-Cost Margins and Market Structure," Economica. Vol. 43, 1979, pp. 267-74.

Cowling and Waterson find fault with studies that relate market structure to performance without using well-defined theoretical models, since they omit relevant variables such as the industry price elasticity of demand. Implicit in this omission is the assumption that demand elasticities are constant across industries within a cross-section. They suggest that the focus of analysis be shifted to *changes* in structure affecting *changes* in performance, since industry price elasticities are more likely to be constant over time than across industries. They then proceed to develop a theoretical model by which changes in the price-cost margin may be explained. Assuming profit maximization, N firms, and a single homogeneous product, they derive an equation in which the markup of price over marginal cost (Lerner's measure of monopoly power) is inversely related to the number of firms in the industry and the industry price elasticity of demand. Assuming constant marginal costs equal average cost, the first part of the derived equation becomes the ratio of profits plus fixed costs to revenue, while the second part is the Herfindahl concentration index. Thus, the profit to revenue ratio is directly related to the Herfindahl index and inversely related to the industry price elasticity of demand. Given the paucity of data, obtaining a good measure of the price elasticity of demand by industry is difficult. Cowling and Waterson suggest a switch in focus from explaining interindustry differences to intraindustry differences in order to test the theoretically derived relationship. Additional determinants of price-cost margins, such as changes in entry barriers, growth of countervailing power, change in unionization, scale economies, and cyclical effects, were discussed, including their effect on the basic model. The model was estimated using an all-industry sample, in addition to a durable versus nondurable breakdown. Results indicate that for durables, the price-cost margin changes are significantly related to changes in concentration, whereas for nondurables, they are not. The Herfindahl index was found to perform better than the four-firm concentration ratio.

(62) Diewert, W.E. "The Comparative Statics of Industry Long-Run Equilibrium," Canadian Journal of Economics. Vol. 14, 1981, pp. 78-92.

Assuming only very weak regularity conditions, Diewert presents a rigorous proof of a theorem put forth by Samuelson (84): as firm output becomes large, average cost using replicable plants approaches the minimum average cost. He proceeds to show graphically that a producer who can replicate plants at constant cost will have a total cost curve equal to the minimum of the cost curves and that the envelope average cost curve rapidly approaches the straight-line asymptotic marginal cost curve as output increases. By demonstrating how the asymptotic, constant-returns-to-scale-technology production function can be constructed from the plant production function, he shows that the above theorem provides the justification for assuming that an industry's technology can be characterized by a neoclassical production function. These conclusions are summarized in the following statement: if producers competitively minimize costs, if optimal plant output is small relative to industry output, and if there are no barriers to entry into the industry, then industry behavior can be closely approximated by assuming that producers maximize profits subject to a neoclassical, constant-returns-to-scale production function. Diewert also evaluates the effect of assuming a homothetic plant production function on the above results, noting that in this case, the asymptotic (industry) unit cost function is proportional to the plant unit cost function. Relationships between the plant elasticity of substitution and the elasticity of substitution generated by the asymptotic

production function are explored. Diewert concludes that in general, there will be more input substitutability at the industry level than at the plant level.

(63) Diewert, W.E. "The Elasticity of Derived Net Supply and Generalized Le Chatelier Principle," Review of Economic Studies. Vol. 48, 1981, pp. 63-81.

The concept of elasticity of derived demand for an input has been developed with the assumption of a single output and several inputs. However, in real life situations, firms or industries produce several outputs. Thus, a more useful measure is the elasticity of derived supply for an output where factor and product markets can adjust to changes in prices in the first output. This supply elasticity is derived under the assumption of a multiple-output scenario, existence of fixed factors, and a decreasing returns to scale technology. Rules analogous to those for derived-demand elasticity were obtained: (1) the larger the magnitude of the elasticity of net demand, the larger the magnitude of the elasticity of net supply, (2) as the substitution possibilities between two goods decreases, their elasticity of derived net supply also decreases, and (3) if two goods are both inputs and outputs and the profit share of one increases, the elasticity of derived net supply for this good also increases. This study also provided a generalization of the Le Chatelier principle.

(64) Ferguson, C.E. "Production, Prices, and the Theory of Jointly-Derived Input Demand Functions," Economica. Vol. 33, 1966, pp. 454-61.

Ferguson extends the Mosak-Allen (79, 52) theory of jointly derived demand to include imperfect competition in the product market. Samuelson (84) also relaxed the assumption of perfect competition in product markets; however, he restricted the firm to movement along a given isoquant, that is, firm size remained fixed. Ferguson's analysis is based on the following assumptions: (1) product demand is an inverse function of product price, (2) the firm is a perfect competitor in factor markets, and (3) there is a given production function with positive marginal products which is monotonically decreasing over the relevant range of input quantities. The main results can be summarized as follows: (1) quantity demanded of a factor must always vary inversely with its price, (2) output price will vary directly with factor price if there are only two factors or if there are many inputs and the production function is linearly homogenous, and (3) quantity demanded of a given factor may vary either directly or inversely with the price of another factor. When factors are complementary, quantity will vary inversely. When the factors are competitive, a direct relationship is more likely, the greater the Allen partial elasticity of substitution and the smaller the elasticity of product demand.

(65) Ferguson, C.E. "'Inferior Factors' and the Theories of Production and Input Demand," Economica. Vol. 35, 1968, pp. 140-50.

In this article, Ferguson extends the analysis of his 1966 article to explain the conditions under which output price varies directly with input price and specifies the characteristics of the production function that give rise to the phenomenon. The analysis is similar to that presented by Bear (56), but it is not limited to the case of perfect competition. Inferior factors are first defined: a factor is inferior if an increase in its price leads to an increase in the equilibrium output of the firm. By relating this derivative to elements of the Hessian matrix of the production function, Ferguson shows that commodity price varies inversely with factor price if, and only if, the input is inferior. Using the Hessian relationships, he is also able to establish that homogeneity of the production function and the input counterpart of gross substitutability for outputs preclude factor inferiority. Cross elasticities of demand are also related to factor inferiority; the weighted sum of the cross price elasticities is positive if, and only if, the factor is inferior. The results thus far pertain to the derived input demand functions of the profit-maximizing firm. Imposing the less stringent behavioral assumption of output maximization subject to an expenditure constraint, Ferguson derives some additional results. Marginal cost is found to vary inversely with input price for an inferior factor. The effect of a change in own input price on input quantity is divided into substitution and output effects. The substitution effect is always negative, but the sign of the output effect is found to depend on the normality or inferiority of the factor. However, Ferguson notes, the statement "there may exist a range of values over which the individual firm's demand curve for an input is positively sloped" is not justified by this result because the slope of the input demand function is derived from the assumption of profit

maximization which, Ferguson asserts, is the only true demand function. Ferguson supports Hicks' (74) observation that an inferior factor is simply one that is more suitable at low levels of output than at high ones. Ferguson concludes that, while of theoretical importance, the empirical importance of factor inferiority is difficult to assess.

(66) Ferguson, C.E. The Neoclassical Theory of Production and Distribution. Chapters 2, 3, 4. Cambridge, MA: Cambridge University Press, 1979.

The theory of production under fixed proportions is the topic of chapters 2 and 3, while chapter 4 addresses the case of variable proportions. Limitational and limitative inputs are defined in the text introduction, laying the groundwork for a discussion of technological characteristics distinguishing fixed from variable-proportion production functions. More specifically, the second chapter presents the technical theory of production under fixed-proportion stressing the differences between production using elementary inputs and that using complex inputs. The discussion of elementary inputs distinguishes between the case of fixed proportions most often treated in the literature, namely that of fixed coefficients where the production function is linearly homogeneous, and the case where increasing or decreasing returns to scale are exhibited even though the production function is of the fixed proportions variety. Differences in average and marginal products for cases of limitational, limitative, mutually limitational, and redundant inputs are presented. An example of production with complex inputs follows. The section on complex inputs also includes discussion of the Pareto and economic regions of production, and the elasticity of substitution. The final section of chapter 2 outlines the theory of production with elementary inputs and multiple production processes. Ferguson demonstrates that input substitution is possible in many kinds of fixed-proportion technologies. Chapter 3 considers the economic theory of production under fixed proportions. Ferguson notes that the presence of fixed-input proportions establishes a technological ray; thus, economic considerations do not play so crucial a role as when production is subject to variable proportions. Finally, in chapter 4, Ferguson generalizes the analysis of fixed-proportion-type production functions to include all discontinuous production functions. Marginal rates of technical substitution, production isoclines, substitution regions, and the elasticity of substitution are among the topics covered.

(67) Ferguson, C.E., and Thomas R. Saving. "Long-Run Scale Adjustments of a Perfectly Competitive Firm, and Industry," American Economic Review. Vol. 59, 1969, pp. 774-83.

In this article, Ferguson and Saving address an area of the theory of competition previously neglected: the longrun responsiveness of firm and industry output to a change in factor price. Specifically, the authors prove the following: (1) a firm's shortrun and longrun output response to a factor price change depends on the expenditure elasticity of the factor and not its classification, (2) regardless of the change in marginal cost, average cost must vary directly with factor price, and (3) the longrun supply price of a perfectly competitive industry always varies directly and its output inversely, with a factor price change. The classification of inputs as normal, inferior, and superior is related to their expenditure elasticities. Parallels are drawn between the supply-expenditure elasticities and substitution-expenditure effects of producer theory and their counterparts in consumer theory. The longrun equilibrium output of a perfectly competitive firm is shown to vary directly with the price of an inferior or normal input and inversely with the price of a superior input. Although contrary to conventional wisdom, Ferguson and Saving note that the explanation of this result follows intuitively when the relationship between the expenditure elasticity of a factor and the change in its relative share is considered that is, with an increase in factor price, there will be an increase in output and a decrease in the relative share of the more expensive factor if the factor is normal or inferior. It is stressed that these results do not imply that longrun equilibrium output increases as well. Longrun industry price is shown to increase and longrun equilibrium output must decrease with an increase in factor price, regardless of factor classification. This outcome is contrary to the shortrun result which depends on factor classification. Mathematical proofs are followed by graphical summaries of the main results. Implications of the limiting cases when expenditure elasticities are equal to zero or one are discussed and proved in the appendix. As noted, in a competitive industry, longrun equilibrium price always varies directly, and equilibrium output inversely, with factor price. Only within the individual firm will longrun adjustment depend on the expenditure elasticities of the input. Results can be summarized as follows for inferior, normal and superior factors: longrun marginal cost varies inversely, directly, and

directly, respectively, with factor price changes; while equilibrium output varies directly, directly, and inversely, respectively.

(68) Floyd, John E. "The Effects of Farm Price Supports on the Returns to Land and Labor in Agriculture," Journal of Political Economy. Vol. 73, 1965, pp. 148-58.

A market equilibrium approach is taken to examining the effects of farm price supports on the returns to land and labor in agriculture. The model used in the analysis is a six-equation model describing supply-demand relationships in the market for agricultural output and the factor markets for land and labor. The model extends a previous effort by Brandow (3), and is similar in structure to a model used by Muth (81) to develop comparative statics results for derived demand and industry supply. The basic model framework in this article was also used by Gardner (22) to develop implications of market equilibrium for the relationship between retail and farm food prices.

(69) Friedman, Milton. Price Theory. Chapter 7. Hawthorne, NY: Aldine Publishing Co., 1976.

Friedman reviews Marshall's theory of joint demand. Graphical derivations of derived demand for a factor of production are presented assuming fixed proportions between the two factors. Using this analytical framework, Freidman demonstrates Marshall's four principles governing the elasticity of the derived demand curve, namely, derived demand for any factor used in fixed proportions with the other factor will be more inelastic when: (1) the more essential the factor in question (this is guaranteed in the extreme case of fixed input proportions), (2) the more inelastic is the demand curve for the final product, (3) the smaller the fraction of total cost that goes to the factor in question, and (4) the more inelastic the supply curve of the other factors. Friedman points out that this framework will be most useful when changes in proportions of factors is least important for the problem at hand. This means the theory of joint demand under fixed proportions is most applicable for shortrun adjustment problems. The longer the time allowed for adjustment, the greater the error will be from neglecting changes in factor proportions.

(70) Friedman, Milton. Price Theory. Chapter 9. Hawthorne, NY: Aldine Publishing Co., 1976.

The relationships between different factor demand curves of the firm and industry are derived. At the firm level, the demand curve for a factor (holding output price and prices of other factors constant) is flatter than the curve constructed holding quantities of other factors constant (value marginal product curve), which in turn is flatter than the demand curve constructed holding output of the firm constant (output constant demand curve). The industry factor response, which takes account of the change in factor price on equilibrium output price, falls between the factor responses of two types of demand curves: the flattest demand curve is constructed as the horizontal summation of individual firms' demand curves holding output price constant, while the steepest demand curve is constructed as the horizontal summation of individual firms' demand curves holding output levels of individual firms constant. In this analysis, other factor prices are assumed to be constant in response to a change in the price of the factor in question.

(71) Heiner, Ronald A. "Theory of the Firm in 'Short-Run' Industry Equilibrium," American Economic Review. Vol. 72, 1982, pp. 555-62.

The longrun input behavior of the competitive industry has been the subject of numerous studies. Heiner presents a complementary analysis of the shortrun case in which technology and the number of firms are fixed, but industry output price responds to aggregate supply changes of existing firms that resulted from changes in factor prices. Heiner shows that the results obtained for industry-factor demands do not necessarily hold for individual firms when they jointly respond to factor prices with other firms in the industry. His analysis is in contrast with traditional methodology where factor demand responses are derived from firms acting in isolation and then the isolated responses are aggregated to obtain the industry factor demand response. The stated purpose of the article is to characterize the shortrun industry level factor demand implications and show how these implications relate to the traditional theory of isolated firm behavior. In relating traditional factor demand theory to shortrun industry factor behavior, Heiner considers two polar cases: (1) infinitely inelastic industry output demand so that output price adjusts to keep industry output constant, which corresponds to the cost-minimizing inputs for fixed output, and (2)

infinitely elastic industry output demand so that industry supply changes have no effect on output price, which corresponds to the profit maximizing inputs for fixed output price. The Heiner shortrun industry factor response falls between these extremes. Manipulation of an identity relating these two cases yields the firm's shortrun factor demand, which incorporates the effect of output responding to price, so as to equate industry supply and demand. Heiner demonstrates that the shortrun factor response of an individual firm within the industry can be divided into three separate components: the output constant effect (the factor response for constant firm output), the output response effect (the change in profit-maximizing supply for fixed output price), and the output price response effect (the change in the market clearing output price). The first two effects together represent the profit-maximizing factor response under the traditional assumption of fixed output price. By examining the signs of these individual effects, Heiner shows that the own-price factor response of a firm (influenced by shortrun market clearing and output price adjustments) can violate the law of demand even in the case of all normal factors of production. These problems cancel out when summed over all firms and thus, at the industry level, factor demand curves are always negatively sloped. These results follow without assumptions limiting interfirm diversity; that is, a factor could be inferior to some firms, yet normal to others, and the industry level results would still hold. Finally, Heiner discusses how shortrun results imply that the law of input demand is likely to hold at the industry level even when entry and exist from the industry occurs.

(72) Henderson, James M., and Richard E. Quandt. Micro Economic Theory, A Mathematical Approach. Chapter 4. Second edition. New York: McGraw Hill Book Co., 1980.

Henderson and Quandt discuss the derived input demand functions obtained from solving the first order conditions of the unconstrained profit-maximization problem. The properties of these functions are outlined and an empirical example using a Cobb-Douglas functional form is given. Comparative statics examining the effect of changes in input and output prices on factor demand are presented. The own-price effect is shown to be always negative, indicating that producers' input demand curves are always downward sloping. Henderson and Quandt note that in the theory of the profit-maximizing producer there is only a substitution effect; no counterpart for the income effect in consumer theory exists. The signs on the cross-price effect and the effect of output price on input demand are ambiguous; however, they argue that the former is usually negative, while the latter is normally positive. The authors next illustrate the Le Chatlier principle for the two-input case, that is, the absolute value of demand reduction, following a price increase, cannot be increased as additional constraints are introduced and may be decreased. The effect of an increase in the wage rate on a firm's demand for labor in the long run, with capital variable, is compared with the shortrun effect when capital is fixed. Longrun employment reductions are shown to be greater than the shortrun reductions.

(73) Hicks, J.R. "Marshall's Third Rule: A Further Comment," Oxford Economic Papers. Vol. 13, 1961, pp. 262-65.

Bronfenbrenner (59) accused Hicks of deriving the mathematics necessary to analyze the exception to Marshall's third law, without coming to grips with common sense. In response to this criticism, Hicks focuses on the meaning of the $\eta > \sigma$ condition in this note. First, to review and complete his earlier work, a formula is added for the cross elasticity of derived demand [$\mu = K(\eta - \sigma)e/K\sigma + (1\text{-}K)\eta + e$] which, as in the case with the own-derived-demand elasticity, reduces to the Allen (52) formula as supply elasticity approaches infinity and to something very similar when it approaches zero. In the remainder of the paper, Hicks discusses the intuition behind "the one thing of possible economic importance which emerges from these formulae." The condition $\eta > \sigma$ is the condition for an increase in the supply of factor A to increase the demand for factor B. Hicks uses the example of two factors (A and B) that are highly substitutable (for example, two types of labor), with prices w_A and w_B. An increase in w_A (w_B held constant) will decrease A, and if $\sigma > 0$, then two forces will be at work on B (a substitution effect and an output effect). Hicks states that an increase in w_A when $\eta > \sigma$ is bad for B, whereas when $\eta < \sigma$, this increase is good for B. The reasoning is as follows. If K (factor A's share of total costs) is large, then 1-K (B's share) is small and a relatively small increase in K results in a relatively large decrease in 1-K. This only comes about with difficulty if $\eta > \sigma$, thus, the "importance of being unimportant." A can increase w_A more easily, the more easily B can be squeezed and this occurs when K is small, providing $\eta > \sigma$. In the case of $\eta < \sigma$, if K is large (so that 1-K is small), then part of what A gets from the consumer (that is,

the consumer pays for increases w_A with increases in output price) must be shared with B. An increase in 1-K in this case has little effect on A. A less artificial example suggested by Hicks would include three factors: two types of labor and capital. In conclusion, the demand for A will be more elastic the larger K if $\eta > \sigma$ and less elastic the larger K if $\sigma > \eta$.

(74) Hicks, J.R. The Theory of Wages, Appendix pp. 233-47. Second Edition. New York: St. Martin's Press, 1966.

Wicksteed argued that fulfillment of the law of marginal productivity (total product is exactly exhausted if each factor is paid according to its marginal product) requires a linearly homogeneous production function. Using Walras' and Wicksell's approach, Hicks proves that this result is independent of the constant returns to scale assumption. Only two assumptions are necessary: (1) perfect competition in input and output markets and (2) the firm must be in equilibrium (marginal cost equals minimum average cost equals output price). A horizontal average cost curve, he states, is not a necessary condition, only that the average cost curve has a minimum point and that output should be in equilibrium at this point. Hicks extends Marshall's (75) laws by relaxing the assumption of fixed-factor proportions. Assuming equilibrium conditions, a perfectly competitive industry composed of identical firms and a two-input case with factors a and b, the elasticity of derived demand for factor a is given as:

$$\lambda = \frac{\sigma(\eta + e) + Ke(\eta - \sigma)}{\eta + e - K(\eta - \sigma)}$$

where σ = the elasticity of substitution, η = the elasticity of product demand, e = the elasticity of supply of b, and K = the cost share for factor a. Using the above formula, the partial derivatives of λ with respect to σ, e and η are always positive and thus consistent with Marshall's first, third, and fourth rules. Hicks shows that the elasticity of derived demand will become larger or smaller as the cost share increases, depending on the relative magnitudes of η and σ. Thus, Marshall's second law is only true if $\eta > \sigma$. (Hicks assumes e to be positive.) The case of $\eta < \sigma$ is described as a situation in which technical change is easy, while product demand is inelastic. In other words, it is "important to be unimportant" only when the consumer can substitute more easily than the entrepreneur. [Note: In Theory of Wages, Hicks uses A.C. Pigou's (Economics of Welfare) re-statement of Marshall's four laws, which interchanges Marshall's second and third laws, the latter being Marshall's law that it is "important to be unimportant."]

(75) Marshall, Alfred. Principles of Economics. Chapter 6. Eighth edition. New York: Macmillan and Co., Ltd., 1920.

Chapter six of this book deals with the issues of joint and composite demand and supply. Marshall begins by differentiating between the concepts of direct, derived, and joint demand. Assuming direct demand and the supply of other factors is unchanged, he isolates the effect of a change in the supply of one factor of production. Marshall states the law of derived demand as follows: the demand schedule for any factor of production can be derived from that for the commodity by subtracting from the demand price of each separate amount of the commodity the sum of the supply prices for corresponding amounts of the other factors. A diagrammatical illustration of the derivation of the factor demand curve from the direct demand curve is given for the case of fixed proportions. Marshall reminds the reader that in applications, if the supply of one factor is disturbed, the supply of others is likely to be disturbed. Marshall presents the conditions under which "a check to the supply of a thing that is wanted not for direct use but as a factor of production may cause a great rise in its price". Namely, a rise in factor price will result if: (1) the factor is essential to production, (2) commodity demand is inelastic, (3) the factor is a small share of total production expenses, and (4) a small decrease in amount demanded should considerably decrease the supply prices of other factors of production. The moderating influence of the substitution of one factor for another and the effects of relaxing the assumption of fixed input/output proportions are mentioned. Finally, the concept of rival demands is discussed before proceeding to the case of joint products. The analysis of joint supply mirrors that of demand.

(76) Maurice, Charles S. "On the Importance of Being Unimportant: An Analysis of the Paradox in Marshall's Third Rule of Derived Demand," Economica. Vol. 42, 1975, pp. 385-93.

Despite general acceptance of Hicks' (73) caveat to Marshall's (75) third rule of derived demand (it only holds when the elasticity of product demand is greater than the elasticity of substitution), there has been considerable confusion and controversy concerning the reasons behind the exception. A brief review of the myriad of papers on this topic is provided to demonstrate that the reasons for the caveat have never been completely or rigorously set forth. Maurice provides the explanation. Hicks' two-input model, which results in the expression for a change in the elasticity of derived demand with respect to a factor share change ($\partial\lambda_a/\partial k_a = \eta\text{-}\sigma_{ab}$) is first outlined, followed by the n-input Allen (52) model. Maurice points out that the Allen model, seemingly derived under the same assumptions, leads to a different conclusion than the Hicks model. The difference is due to the particular elasticity of substitution that is held constant: the own-elasticity of substitution, or cross-elasticity of substitution. Hicks' caveat follows from the way in which certain variables are forced to change. Writing the derived demand function in implicit form emphasizes the fact that all variables are uniquely determined: something exogenous to the system must change for the factor share to change and since the variables are not independent of each other, if relative shares change they must change subject to some constraints. As a result of these constraints, no matter how the relative shares change, the slope of the isoquant must change and the way it is forced to change determines the difference in results depending on what is held constant. Thus, the differences in results can be explained by analyzing what happens to the rate at which the substitution effect changes with changes in the factor share under different assumptions. In other words, the way in which the isoquant is forced to change determines the results, and thus Hicks' caveat is not incompatible with the work of Allen and others. In the final section of the article, Maurice takes issue with Bronfenbrenner's (39) attempt to demonstrate that Hicks' exception is internally contradictory because it is inconsistent with competitive equilibrium and implies negative shares; Bronfenbrenner's argument, he states, is in error itself due to internal contradictions.

(77) McFadden, Daniel. "Cost, Revenue, and Profit Functions," Production Economics: A Dual Approach to Theory and Applications. Chapter 1. M. Fuss and D. McFadden (eds.). Amsterdam: North-Holland, 1978.

This chapter explores the fundamental duality between cost and production functions. The first section contains a discussion of the theory of cost functions and its applications while the second part presents a more rigorous technical analysis of the properties of restricted profit functions. McFadden begins with a brief history of duality and some basic definitions (production possibilities set and input requirement set) before turning to the regularity conditions and their importance. He next defines the cost function itself and discusses its properties and their implications. Shepherd's (41) lemma is presented and proved along with other derivative properties (for example, symmetry). McFadden replicates a number of duality results that were first proved by Shepherd and Uzawa. In addition, distance functions, extension of basic duality results, Cobb-Douglas and CES examples of cost functions, the geometry of two-input cost functions and the comparative statics of cost minimization, are all addressed in the first section. The restricted profit function is the subject of the second part of this chapter. Cost, revenue, and unrestricted profit functions are all shown to be special cases of the restricted profit function.

(78) Morishima, M. "A Note on a Point in Value and Capital," Review of Economic Studies. Vol. 21, 1953-54, pp. 214-17.

In Value and Capital, Hicks states that if fixed resources of the entrepreneur limit the scale of production, then: (1) all factors employed are complements, (2) all products are complements, and (3) all factor-product relations are substitutive. From these propositions, he concludes that if the fixed resources of the entrepreneur have no important effect in limiting production, then the entrepreneur will increase his/her supply of each product and his/her demand for each factor when there is a rise in the price of some product. The purpose of this note is to demonstrate the fallacy of this conclusion and examine the conditions which are, in fact, sufficient for the above proposition. Alternative definitions of technical complementarity and substitution, which are often confused in Value and Capital, are presented first. Morishima then proves that a technological transformation function, that is homogenous of degree zero, is

not a sufficient condition for the above Hicksian propositions. The conditions that are sufficient for three separate cases are: the one-product case, the two-product case, and the case of production with several transformation functions. For the one-product, multiple-input case where two factors are complementary and any two factors are co-operant with each other, Morishima easily proves that propositions 1-3 necessarily hold. He next considers the two-product, multiple-input case, where any two factors are co-operant with respect to the first product, along with the assumption that the quantity of the product increases when the quantity of one input increases (with quantities of all other inputs fixed and the marginal product of the input in terms of the other output unchanged). If it is also assumed that the marginal rate of substitution between products is diminishing, then the above proposition can be shown to hold. Finally, Morishima examines the case with several transformation functions, under the assumption that the number of transformation functions is not less than the number of products. He shows that with a number of additional assumptions, propositions 1-3 will hold.

(79) Mosak, Jacob L. "Interrelations of Production, Price and Derived Demand," Journal of Political Economy. Vol. 46, 1938, pp. 761-87.

Mosak describes the problem facing the individual producer as twofold: (1) maximizing output subject to a given level of expenditures (the technical problem), and (2) choosing the level of expenditures that maximizes net revenue (the economic problem). Assuming perfect competition, the first- and second-order conditions for both problems are presented. Total differentiation of the equilibrium input quantities and total cost, followed by substitution and collection of terms, yields an expression for the change in the quantity demanded of a factor of production as a function of changes in all factor prices and output price. The total variation in demand for a factor of production is shown to consist of two parts: (1) the direct effect due to changes in input price when no account is taken of the resultant variation in total cost, and (2) the indirect effect due to the resultant change in total cost. Throughout the analysis, special attention is paid to the similarities and differences between the theory of production and the theory of consumer choice. The economic problem, it is noted, constitutes the point of departure between the two, a fixed budget is not assumed in the theory of production. Other important findings include: (1) the slope of an individual producer's factor demand curve with respect to own price is always negative (in contrast to the demand curve for consumers which may be positively sloped), (2) the slope of the product supply curve with respect to product price is positive, (3) the total change resulting from a change in the price of one factor equals the total change in demand for the second factor with respect to a change in the price of the first, (4) substitution (along a given isoquant) of factor i resulting from a change in price of factor j equals the substitution of factor j resulting from a change in price of factor i, that is, symmetry as in the theory of consumer choice, (5) the total effect on output of a change in input price j equals the negative of the effect of a change in output price on input factor j, and (6) the sum of the output elasticities with respect to input prices equals the negative of the elasticity of supply.

(80) Mundlak, Y. "Elasticities of Substitution and the Theory of Derived Demand," Review of Economic Studies. Vol. 35, 1968, pp. 225-36.

Mundlak relates various definitions of the elasticity of substitution (ES) to the general theory of factor demand and uses this as a basis for exploring relationships between definitions. Results from Mosak's (79) study of three derived demand curves (output constant, cost constant, and marginal cost constant) are summarized first: (1) the proportionate effect of a change in the price of the j^{th} factor on cost, with output held constant, is equal to the share of the j^{th} factor in total cost, (2) the proportionate effect of a change in the price of the j^{th} factor on output, with cost held constant, is equal to the production elasticity of that factor, and (3) the proportionate effect of a change in the price of the j^{th} factor on output, with marginal cost held constant, times the revenue/total cost ratio is equal to the proportionate effect of a change in the price of the j^{th} factor on costs, with marginal costs held constant, minus the share of the j^{th} factor in total cost. These relationships were then used to define one-factor/one-price, one-factor/two-price and two-factor/two-price measures of ES. Mundlak refers to the one-factor/one-price measures as the Allen framework (52). Of the three one-factor/one-price definitions, only the one corresponding to the output-constant demand curve measures response along a given isoquant; the other two definitions contain expansion effects and, therefore, do not measure pure substitution along an isoquant. The two-factor/two-price measures corresponding to output, cost, and marginal cost constant, demand curves are shown to be

the same; if, and only if, the production function is homothetic with respect to the two inputs in question. This equality is shown to hold under the same conditions for the two-factor/two-price definitions of ES. The two-factor/two-price definitions of ES are shown to depend on the relative magnitude of the price changes except in the two-input case or when the production function is separable. For the two-factor case, Mundlak proves that the elasticity of substitution is independent of the way in which price changes. By considering specific changes in price, Mundlak derives an expression for McFadden's (77) shadow ES in terms of the Allen (52) ES and relates it to definitions corresponding to the output and cost constant demand curves. The output constant ES is shown to be equal to the shadow ES when there are only two factors. Although the ES corresponding to the constant marginal cost demand curve will differ from the other two under the above conditions, Mundlak does demonstrate that there are conditions under which the constant marginal cost ES will equal either the constant output or the constant cost ES. Shortrun elasticities of substitution are also discussed. Mundlak defines the direct ES which, when there are more than two factors, measures the substitution along an isoquant, with all other inputs held constant.

(81) Muth, Richard F. "The Derived Demand for a Productive Factor and the Industry Supply Curve," Oxford Economic Papers. Vol. 16, 1964, pp. 221-34.

Using an analysis similar to Hicks' (74), Muth derives the elasticity of industry supply as well as coefficients of other determinants of supply and factor demand. A six-equation industry equilibrium model is constructed consisting of equations for product demand and supply, factor supplies, and equilibrium conditions equating the price of each factor with its marginal value product. The following assumptions were made in specifying the model: (1) the industry consists of a group of actual or potential producers of a single homogenous product, (2) the firms within the industry have identical production functions and use two factors of production that are unspecialized to any firm, but specialized to the industry, (3) there are no external technological effects so the production possibilities open to each firm are independent of industry output, and (4) firms are price takers in input and output markets. The implications of these assumptions for the average cost curves of individual firms, where firms will operate along that curve, and the industry production function are discussed. Displacements of the system from the initial equilibrium resulting from shifts in one or more of the equations are considered. The key results from the derivation of the industry factor demand schedule are: (1) an increase in the supply of factor A may either increase or decrease the demand for factor B, depending on the relative magnitudes of the output demand elasticity (η) and the elasticity of substitution (σ), (2) an increase in product demand increases the derived demand for B, (3) a B-saving technological change decreases demand for B, and (4) neutral technological change may increase or decrease the demand for B according to whether output demand is elastic or inelastic. Muth simplifies his derived demand expression and results by considering separately the special cases of an infinitely elastic product demand and factor supply. The following observations stem from the derivation of the industry supply curve: (1) increases in the amount of either factor, or neutral technological change, will increase supply of the product, (2) B-saving technological change will increase or decrease industry supply depending on the relative magnitudes of the factor supply elasticities, (3) no paradoxes comparable to Hicks' were found when differentiating the industry supply elasticity with respect to factor supply elasticities, factor shares, or σ, (4) the elasticity of supply increases with increases in the supply of either factor, or the greater the relative importance of the factor whose supply is more elastic, and (5) the elasticity of supply is greater the greater is σ.

(82) Panzar, John C., and Robert D. Willig. "On the Comparative Statics of a Competitive Industry with Inframarginal Firms," American Economic Review. Vol. 68, 1978, pp. 474-78.

Traditional theory of the perfectly competitive firm and industry in longrun equilibrium recognizes that output must adjust to exogenous changes in input prices, but assumes a horizontal industry supply curve, that is, all firms are identical and when in equilibrium, earn no rents, which allows the analysis to be carried out entirely at the firm level. Panzar and Willig argue that this approach has limited applicability to industry level analysis since it does not allow inframarginal firms and thereby ignores an important class of competitive industries with rising supply curves. The authors develop a simple model of a competitive industry with a rising supply curve by allowing firms to have differing endowments of a fixed factor in inelastic supply. Comparative static results indicate that the effect of an input price change on equilibrium output price is indeterminate. They prove that the sign of this derivative is dependent on the normality or

inferiority of the factor. This result is contrary to previous work by Ferguson and Saving (67) for the case of identical firms, that is, that longrun equilibrium price will always vary directly with output price regardless of the normality properties of the input. An intuitive explanation of these results is offered. In a model which explicitly recognizes the existence of inframarginal firms, the shift in the industry supply curve from a factor price change has two components: the change in the output level of inframarginal firms and the exit of marginal firms. With normal inputs, these operate in the same direction, whereas for inferior inputs, they are opposing forces and the total effect cannot be determined without knowledge of the numbers of marginal and inframarginal firms. They next prove that if an input is inferior and all firms are inframarginal at the initial equilibrium, then output price varies inversely with input price regardless of whether all the firms are identical. Thus, they stress, it is the assumption that all firms are marginal rather than identical, that drives the Ferguson and Saving results.

(83) Portes, R.D. "Input Demand Functions for the Profit-Constrained Sales-Maximizer: Income Effects in the Theory of the Firm," Economica. Vol. 35, 1968, pp. 233-48.

In this article, the analysis of the profit-maximizing firm's demand for inputs is extended to the case of the firm which maximizes sales subject to a profit constraint. Although Baumol and others have studied sales-maximizing behavior, none have provided a detailed comparative statics analysis. Portes begins with a review of the comparative statics results for a profit-maximizing firm. Conclusions with respect to factor inferiority from the works of Hicks (74), Bear (56), Morishima (78), and Ferguson (65), are summarized. The profit-constrained sales maximization model is presented and the system is displaced in a manner that allows consideration of a profit maximizer and a sales maximizer simultaneously. By requiring that the profit maximizer produce at the same output level a sales maximizer would choose in equilibrium (so that they choose the same input mix), Portes derives a relationship between the two-input demand functions. Differentiation of this relationship with respect to the j^{th} input price yields the precise analogue to the Slutsky equation: the effect of a change in the price of input j on the sales-maximizer's demand for input i can be broken down into substitution and income effects. Portes presents an intuitive interpretation of the income effect which makes the analogy with consumer demand theory obvious. In a sales-maximizing model, the profit constraint generates income effects in precisely the same way as the budget constraint generates them in consumer theory. It is noted that the firm under the classical assumptions can choose freely both its isoquant and its isocost line, but the sales maximizer is constrained by the profit requirement which creates the parallel with consumer theory. Portes also examines the effect of changes in input prices on input demand and output, and compares these results with the behavior of profit maximization. Two key differences are noted. For a sales maximizer, there is the possibility of a positive income effect which can outweigh the substitution effect resulting in a Giffin input, and the effect of a change in input price on output is indeterminate.

(84) Samuelson, Paul A. Foundations of Economic Analysis. Cambridge, MA: Harvard University Press, 1947.

Samuelson objects to the standard presentation of cost and production theory, arguing that economic theory has become segmentalized resulting in a deemphasis of the interdependence of economic forces. As an example, he points to the conventional methodology of determining optimal output by equating marginal revenue and marginal cost. Only later is the problem of factor demand investigated, leaving its relationship to marginal cost unclear. It is this approach that Samuelson set out to remedy by addressing the following questions: (1) how are total costs and marginal costs affected by changes in output or factor prices, (2) on what properties of the production function does this depend, and (3) what is the reaction of factor demand to a change in own price, another factor price and output. The first- and second-order conditions for cost minimization, subject to an output constraint, are outlined and discussed. By displacing these equilibrium conditions, Samuelson shows the following: (1) price effects are symmetric, (2) factor demand curves are downward sloping, (3) for total cost to be a minimum at any given output, the price of each factor must equal its marginal physical product times marginal cost regardless of revenue considerations, (4) the change in any input with respect to an increase in output must equal the change in marginal costs with respect to a change in the price of that input, (5) the slope of the marginal cost curve must have the same or opposite sign as the Hessian of the production function, depending on whether the number of inputs is odd or even, (6) input demands are homogeneous of degree zero in input prices

(output constant), and (7) the derivative of the total cost function with respect to factor price equals the input quantity.

(85) Saving, T.R. "Note on Factor Demand Elasticity: The Competitive Case," Econometrica. Vol. 31, 1963, pp. 555-57.

Assuming a profit-maximizing model, identical firms, and that the number of firms remains constant, Saving derives three types of own-factor demand elasticities (constant output; value marginal product relationship; and restricted, meaning at least one fixed factor). Each are derived under conditions of both perfectly elastic and less than perfectly elastic product demand. The relative magnitudes of these elasticities are then compared to determine the effect of: (1) the assumptions on factor variability, and (2) the technical relationship between factors. The technical relationship between factors is given by the sign on the second cross-partial derivative of the production function. Only the value marginal product elasticity (under both product demand conditions) was found to be independent of the sign of the cross-partial derivative. Thus, Saving concludes, both positive and negative values of cross-partial derivatives must be considered when evaluating the relative magnitudes of the elasticities. Saving also looks at the cross elasticity of demand for the composite factor (A_2) with respect to a change in the price of A_1 and finds that the smaller the product demand elasticity, the smaller the chance that the factors will exhibit a complementary relationship. Finally, the relationship between the degree of factor substitutability and the factor demand elasticity is evaluated (Marshall's (75) first law). Only for the constant output elasticity is the relationship unambiguously positive. But, the restricted elasticity does indicate that the lower the product demand elasticity, the more likely increasing substitution will increase demand elasticity.

(86) Silberberg, Eugene. "The Theory of the Firm in 'Long-Run' Equilibrium," American Economic Review. Vol. 64, 1974, pp. 734-41.

This article provides a simple, yet thorough analysis of a firm in a competitive industry, that is, a firm facing zero entry and adjustment costs. Duality theory is used to derive the main results. This method of analysis allows one to avoid complicated manipulations of bordered Hessian determinants as in previous publications, such as in Ferguson and Saving (67). Through this analysis, all the restrictions on relative factor demands (the inverses of the average products) are derived. For these demand relations, the usual properties of downward-sloping demand curves and reciprocity relations associated with production theory are shown to be valid. These properties are shown to be valid for ordinary factor demand curves only in the case of homothetic production functions.

(87) Stigler, George J. The Theory of Price. Chapter 14. Third edition. NY: Macmillan Co., 1966.

The concept of marginal value product is presented and its relationship to factor demand curves discussed. A distinction is made between two types of firm demand curves: the demand curve of a firm when factor price varies only for the individual firm and the demand curve when factor price varies for all firms. The industry demand curve is then defined as the horizontal summation of the latter type of individual firm demand curves. The laws of derived demand are presented and discussed in an intuitive fashion. The exception to Marshall's (75) third law is noted and explained. Shortrun elasticities of factor demand are then briefly compared with the longrun elasticities. The final pages of this chapter deal with factor demand under monopoly. It is noted that two of Marshall's laws carry over from the competitive case: the demand for a factor will be more elastic the better the substitutes for it and the greater the elasticity of the marginal revenue curve. The fourth law must be modified somewhat in the monopolistic case: the demand for a productive service will be more elastic the more elastic the marginal costs of the other services.

(88) Syrquin, M. "A Note on Inferior Inputs," Review of Economic Studies. Vol. 37, 1970, pp. 591-98.

Syrquin notes that although Mosak (79) and Bear (56) proved independently that a decrease in the price of an input will result in a decrease in profit-maximizing output if, and only if, the input is inferior, the possibility of inferiority has not always been recognized. Ambiguities arise from ignoring the possibility of inferiority or failing to see its implications; for example, that both substitution and expansion effects of a

price change go in the same direction has been overlooked. Thus, Syrquin feels another examination of these issues is warranted. In the first section of the article, a simple proof of the proposition that a decrease in the price of an input will decrease the profit-maximizing output of a competitive firm if, and only if, the input is inferior, is provided. This proposition, along with the knowledge that output and inferior input usage are inversely related (all input prices constant) since an increase in output price increases output quantity and decreases usage of inferior inputs, provides the information for a simple explanation of the necessity for a negative slope for input demand. Thus, in the next section, substitution and expansion effects are derived and their equality as to sign explained. The breakdown of the effects of a change in the price of an input on its demand, into substitution and income effects, reveals the symmetry between the consumer and the firm and dispels the notion, that in the theory of the firm, there are only substitution effects with nothing parallel to the income effect of the consumer. The final section of the article gives a graphical exposition of the following proposition: if one of the inputs is inferior over a certain range, then for some finite changes of the output's price, the response in output may be larger in the short run than the long run; along with other implications of an input's being inferior.

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